Effect of Scavenging and Protein Supplement on the Feed Intake and Performance of Improved Pullets and Laying Hens in Northern Vietnam

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ABSTRACT : Two feeding trials were conducted with 128 pullets from 4 to 20 weeks of age and 96 laying hens from 23 to 63 weeks of age to evaluate the effects of scavenging and type of protein supplement on the feed intake and performance of improved pullets and laying hens. The experiments had a completely randomized design with four dietary treatments and four replicates. Treatments were: Control (Cont), scavenging but with access to a balanced concentrate at night; confinement (CF) and given the control feed *ad libitum*; scavenging and supplemented at night with the control feed, but with soybean meal replaced by cassava leaf meal (CLM); scavenging and supplemented at night with the control feed, but with fishmeal replaced by soybean meal (SBM). The mean daily dry matter (DMI), metabolizable energy (MEI) and crude protein intakes (CPI) of the pullets and laying hens, respectively, were 28%, and 18% higher for the confinement treatment (CF) compared to the scavenging treatments ($p<0.001$). The DMI, MEI and CPI of the pullets were not significantly different among scavenging treatments ($p>0.05$), but for the layers DMI, MEI and CPI were significantly higher for the CLM and SBM treatments compared to the Cont treatment ($p<0.001$). In the growing period, the average daily weight gain (ADG), supplement feed conversion ratio (FCR) and supplement feed cost/kg eggs (FCS) were not significantly different for CF compared to Cont, and among scavenging treatments ($p>0.05$). In the laying period, the hen-day production was significantly lower, and supplement FCR and FCS significantly higher for the CF compared to the scavenging treatments ($p<0.001$). Egg weight, and yolk, albumen and shell percentage and shape index were not significantly different among the scavenging treatments ($p>0.05$). However, shell and yolk percentages were significantly lower for the CF compared to the Cont treatment ($p<0.01$). Mortality was significantly higher for the CF compared to the scavenging treatments for pullets, and was significantly lower for the CF compared to scavenging treatments for laying hens ($p<0.001$). It was concluded that scavenging pullets and layers were getting around 28% and 18%, respectively, of their nutrient requirements from scavenging activities, resulting in correspondingly lower supplement feed conversion ratios and feed costs. Daily gains of the pullets were not affected by scavenging or protein supplement, but egg production and mortality were lower for the confined hens. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 11 : 1553-1561)***

Key Words : Scavenging, Protein Supplement, Pullets, Layers

INTRODUCTION

Soybean meal (SBM), fishmeal (FM) and meat meal are the main protein sources in commercial poultry diets in many developed and developing countries. However, an increasing human demand for protein in developing countries and the relatively high cost of imported ingredients has turned attention to the exploitation of non-conventional ingredients and by-products, which these regions have in abundance (D'Mello, 1995). In Vietnam, yellow maize, rice bran and FM are the major ingredients used in poultry feed. However, they tend to be rather scarce and expensive for small producers in the rural areas of Northern Vietnam. This has stimulated poultry nutritionists to search for cheaper, locally available feedstuffs and to investigate their composition and nutritive value. Cassava leaf is abundant and is widely used as a feed resource for livestock in Vietnam. Cassava leaf meal (CLM) can be used as a protein source in poultry diets, and is also included to supply minerals and xanthophyll, but a major limitation of CLM is the presence of hydrogen cyanide (HCN). However, it has been shown in several studies that CLM with low concentrations of HCN can be produced by sun drying or ensiling (Ravindran, 1993; Phuc et al, 2000). The level of inclusion of CLM in practical poultry diets will also depend on the type of ingredients that are being replaced. CLM, as a replacement for coconut meal, was included in layer diets up to the 25% level without adverse effects on egg production, egg quality or feed efficiency (Ravindran, 1990). However, little data is available on the replacement of SBM with CLM in diets for poultry, especially for scavenging pullets and laying hens in Vietnam.

FM is not generally available in rural areas in Vietnam, and when available it is expensive. SBM is a locally available feed resource, widely used in feeds for pigs and poultry in Vietnam. It has a high protein content and fairly good amino acid balance, although the concentrations of methionine and cystine are sub-optimal (McDonald et al., 1995). However, the fact that scavenging birds can find well balanced animal protein sources such as insects and earthworms from scavenging feed resources, should make it possible to replace FM with SBM without reducing the

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Table 1. Experimental design of experiments 1 (pullets) and 2 (layers)

	Treatment[1]							
	Cont 1		CF		CLM		SBM	
	Pullets	Layers	Pullets	Layers	Pullets	Layers	Pullets	Layers
Experiment	1	2	1	2	1	2	1	2
No of birds/treat.	32	24	32	24	32	24	32	24
No of birds/repl.	8	6	8	6	8	6	8	6
Exp. period (wks)	16	40	16	40	16	40	16	40
Initial age (wks)	4	23	4	23	4	23	4	23
Final age (wks)	20	63	20	63	20	63	20	63

[1] Control: Scavenging and a given a balanced concentrate. CF (confined): Confinement and a given the control diet *ad libitum*.
CLM: Scavenging and supplemented with the control diet, but with soybean meal replaced by cassava leaf meal.
SBM: Scavenging and supplemented with the control diet, but with fishmeal replaced by soybean meal.

overall protein content and quality of the diet. Therefore, the effect of including different protein sources in the supplementary feed for scavenging chickens was investigated.

Improved dual-purpose breeds such as the Luong Phuong have been recently imported to Vietnam from China. They have been investigated with respect to performance in confinement (Dat et al., 2001), but little data is available on their performance in scavenging systems.

The aims of the study were to determine the effect of scavenging and replacing soybean meal with cassava leaf meal, and fishmeal with soybean meal in the supplementary feed, on the nutrient intakes, performance and economical efficiency of improved pullets and laying hens.

MATERIALS AND METHODS

Description of the study site

The experiments were carried out from June 2002 to August 2003 at the Goat and Rabbit Research Center, located in Hatay province in Northern Vietnam. Annual rainfall ranges from 1,300 mm to 2,371 mm, of which most falls in a short rainy season from February to April, and in the main rainy season from May to October, with a dry season from November to January. The mean daily temperature ranged from 17.2°C to 29.5°C during the experiment.

Experimental design, treatments and bird management

Two studies were carried out to evaluate the effects of scavenging and supplementation with different protein sources on the feed and nutrient intakes and performance of improved Luong Phuong pullets and laying hens. Experiment 1 (Expt. 1) was conducted from the end of June to early November 2002, with 128 pullets from 4 to 20 weeks of age. Experiment 2 (Expt. 2) was conducted from the end of November 2002 to August 2003, with 96 laying hens from the first experiment from 23 to 63 weeks of age. The birds were allocated randomly to four dietary treatments, with four replicates of eight pullets/replicate and six layers/replicate in Expt. 1 and 2, respectively (Table 1). The experiments were both completely randomized designs with the following treatments: Control (Cont), scavenging but with access to a balanced concentrate at night; CF, total confinement and with the control feed supplied *ad libitum*; CLM, scavenging and supplemented at night with the control feed, but with soybean meal replaced by cassava leaf meal; SBM, scavenging and supplemented at night with the control feed, but with fishmeal replaced by soybean meal. The amounts of the protein supplements were adjusted so that the diets were isonitrogenous.

The birds were vaccinated against some major diseases, such as Newcastle, Mareks and Gumboro disease, and were trained to find their respective pens and nests, and were leg banded for identification. The non-confined groups were allowed to scavenge freely on pasture, under trees, and on sugar-cane fields for about eight to ten hours per day. The experimental pens were open throughout the day, but the feeders were raised during the day and lowered in the evening to give the birds access to the supplementary feeds. During the night all birds were confined in pens of 1.5 m^2 (1.5 m×1.0 m), with an average density of about five birds per m^2, and four birds per m^2 for the pullets and layers, respectively. Feeds for the confined birds were supplied *ad libitum* and residues weighed twice daily, in the early morning and late afternoon. Rice husks on packed-earth floors were used for bedding, and natural light was used in the daytime and artificial light (electric bulbs) at night, with an intensity of 3 Lux at floor level throughout the whole experimental period. One automatic feeder and drinker was placed in each pen, and feeders and drinkers were cleaned and refilled daily in the morning.

Feed and ingredient analysis and diet formulation

The dietary ingredients were analysed at the laboratories of the National Institute of Animal Husbandry in Hanoi, and their chemical composition and nutritive values are given in Table 2. The dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) nitrogen free extractives (NFE) and total minerals (Ash) were analysed according to standard methods (AOAC, 1990). Calcium (Ca) and trace minerals were determined by atomic absorption

Table 2. Chemical composition of the dietary ingredients used in experiments 1 and 2 (g/kg DM basis)

	Maize meal	Rice bran	Soybean meal	Fishmeal	Cassava leaf meal
Dry matter	873	885	915	890	896
Crude protein	89	113	390	597	220
Ether extract	44	114	123	82.4	83.8
Crude fiber	15	124	37	1.7	139
Nitrogen free extract	699	468	297	11.7	397
Ash	14	69	56	241	71.1
Calcium	2.2	2.3	2.3	43.4	10.9
Phosphorus	3.0	12.2	6.3	30.1	6.4
Lysine	2.7	5.6	24	21.3	3.5
Methionine	1.7	2.5	5.4	8.2	1.2
HCN in fresh cassava leaves (mg/kg)					362
HCN in CLM (mg/kg)					91.5
ME (MJ/kg) (calculated)	13.8	10.6	13.1	10.6	10.9

Table 3. Ingredient and chemical composition of the experimental diets for pullets from 4 to 12 weeks of age (g/kg DM)

Ingredient	Cont (CF)	CLM	SBM
Maize meal	520	470	490
Rice bran	290	260	290
Soybean meal	120	0	200
Fish meal	50	70	0
CLM	0	180	0
Vitamin premix *	5	5	5
Mineral premix ** ($CaCO_3$ 40%)	15	15	15
Analysed nutrients			
DM	865	864	867
CP	156	153	154
CF (g/kg)	15.9	35.4	18.3
Calcium	10.3	12.6	8.2
Phosphorus	7.4	7.8	6.3
Lysine	6.9	4.8	7.7
Methionine	2.7	2.2	2.6
ME (MJ/kg)[a]	12.4	11.5	12.5
Cost/kg (VND)	3,057	2,551	3,171

Vitamin premix* (per kg): B_1 250 mg, B_2 600 mg, B_3 4,000 mg, B_6 450 mg, B_{12} 2.5 mg, Biotin 20 mg, Folic acid 150 mg, Pantothenic acid 1,500 mg, Choline 80,000 mg.

Mineral premix** (per kg): Calcium 400 g (40%), Manganese 8,000 mg, Zinc 4,000 mg.

[a] Calculated.

Table 4. Ingredient and chemical composition of the experimental diets for pullets from 12 to 20 weeks of age (g/kg DM)

Ingredient	Cont (CF)	CLM	SBM
Maize meal	510	530	510
Rice bran	340	200	310
Soybean meal	80	0	160
Fish meal	50	50	0
CLM	0	200	0
Vitamin premix	5	5	5
Mineral premix ** ($CaCO_3$ 40%)	15	15	15
Analysed nutrients			
DM	864	863	866
CP	145	144	143
CF	14.9	38.3	17.4
Calcium	10.3	11.9	8.2
Phosphorus	7.7	6.8	6.3
Lysine	6.3	4.3	6.9
Methionine	2.6	2.1	2.5
ME (MJ/kg)[a]	12.2	11.6	12.4
Cost/kg (VND)	2,905	2,461	3,019

Vitamin premix* (per kg): B_1 250 mg, B_2 600 mg, B_3 4,000 mg, B_6 450 mg, B_{12} 2.5 mg, Biotin 20 mg, Folic acid 150 mg, Pantothenic acid 1,500 mg, Choline 80,000 mg.

Mineral premix** (per kg): Calcium 400 g (40%), Manganese 8,000 mg, Zinc 4,000 mg.

[a] Calculated.

spectrophotometer, and phosphorus (P) by continuous flow analysis. Amino acids were analysed according to Spackman et al. (1958) on an ion-exchange column using a high performance liquid chromatographic method. The hydrogen cyanide (HCN) content was determined by a spectrophotometer using barbituric acid pyridine reagent at a wavelength of 620 nm according to O' Brien et al. (1991), and by titration with alkaline silver nitrate (0.1 N $AgNO_3$) (AOAC, 1980). The metabolisable energy (ME) content was calculated from chemical analysis data using the formula of Nehring and Haenlein (1973):

$$ME\ (kcal/kg) = 4.26\ X1 + 9.5\ X2 + 4.23\ X3 + 4.20\ X4$$

Where X1 through X4 are digestible crude protein, digestible fat, digestible crude fibre and digestible nitrogen-free extract. Estimated digestibility coefficients are according to NIAH (1995).

The diets were formulated to meet nutrient requirements (NRC, 1994) for birds of 4 to 20, and 20 to 63 weeks of age. The ingredient and chemical composition of the experimental diets are shown in Table 3 and 4 for pullets, and Table 5 for hens. Mineral and vitamin premixes were mixed with the experimental diets and supplied to all groups.

Data collection and measurements

All chickens were weighed individually every week

Table 5. Ingredient and chemical composition of the experimental diets for laying hens from 20 to 63 weeks of age (g/kg DM)

Ingredient	Cont (CF)	CLM	SBM
Maize meal	490	470	490
Rice bran	275	205	265
Soybean meal	140	0	240
Fish meal	60	90	0
CLM	0	200	0
Vitamin premix*	5	5	5
Mineral premix ** ($CaCO_3$ 40%)	30	30	30
Analysed nutrients			
DM	853	851	856
CP	165	163	164
CF	16.0	37.5	19.0
Calcium	16.7	19.6	14.2
Phosphorus	7.5	7.9	6.1
Lysine	7.5	5.0	8.5
Methionine	2.8	2.3	2.8
ME (MJ/kg) [a]	12.0	11.3	12.2
Cost/kg (VND)[b]	3,168	2,610	3,320

Vitamin premix* (per kg): Vitamin (vit.) B_1 250 mg, B_2 600 mg, B_5 4,000 mg, B_6 450 mg, B_{12} 2.5 mg, Biotin 20 mg, Folic acid 150 mg, Pantothenic acid 1,500 mg, Choline 80,000 mg.

Mineral premix** (per kg): Calcium 400 g (40%), Manganese 8,000 mg, Zinc 4,000 mg.

[a] Calculated. [b] 1 USD=15,000 VND

from 4 to 20 weeks of age for pullets, and the initial weight at 23 weeks of age, and final weight at 63 weeks of age were recorded for the layers. Daily feed intakes were calculated according to the total feed consumption of the group in each pen, and feed offered and refusals were recorded every day to calculate the daily feed consumption. All eggs from 23 to 63 weeks of age were collected daily for each pen, and were weighed to calculate the feed consumption per kg of eggs, and mean egg weight. Egg quality was determined and recorded weekly by randomly selecting five eggs per treatment. Eggshell thickness was determined by micrometer (±0.01 mm) at three points (top, bottom and middle). Egg yolk, albumen and shell weights were determined gravimetrically using an electronic balance (±0.001 g). Shape index was calculated using a Palmer micrometer. Egg production was expressed in terms of the total number of eggs per number of hens alive at that time (hen-day production) for the 40 weeks in lay. The initial number of birds and number remaining at the end of each week were recorded to calculate mortality, and incidences of feather pecking and diseases were observed.

Economic analysis

Economic analyses were carried out using current prices in Vietnamese Dong (VND) to compare the feeding costs of the different treatments, and to calculate mean feed costs per kg live weight gain and per kg egg weight and economic losses due to mortality.

Experimental model and statistical analysis

The data were subjected to ANOVA using the General Linear Model (GLM) of MINITAB Reference Manual Release 12.21 (1998) with the statistical model below. Pairwise comparisons of treatment means were made using the Tukey test.

$$Y_{ijk} = \mu+\alpha_i+\varepsilon_j$$

Where: μ = the general mean
α_i = the ith treatment
ε_j = ε^{th} error term

RESULTS

Chemical composition and nutritive value of the dietary ingredients

The chemical composition and nutritive value of the dietary ingredients are given in Table 2. The maize used in the trial was a yellow variety, and was found to be high in metabolisable energy (13.8 MJ/kg DM), and low in crude fibre (15 g/kg) and crude protein (CP) (89 g/kg). The SBM used was grown locally and had fairly high crude protein (390 g/kg) and lysine contents (24.0 g/kg) but was low in methionine (5.4 g/kg). The chemical composition and nutritive value of the sun-dried cassava leaf meal (CLM) are shown in Table 2. The CP content was 220 g/kg and included 35 g/kg lysine and 12 g/kg methionine. The hydrogen cyanide (HCN) content was found to be 362 mg/kg in the fresh cassava leaf and 92 mg/kg DM in CLM. The FM used in the study had a CP content of 597 g/kg. The calculated ME content of the CLM was low (10.6 MJ/kg), and this resulted in the CLM diets having ME concentrations between 0.6 and 1.0 MJ/kg lower than the Cont and SBM diets.

Experiment 1 (pullets)

Climate data : Mean daily maximum temperatures for July, August, September and October 2002 were 30.0, 28.7, 27.4 and 24.9°C, respectively, and monthly rainfall 172, 200, 149 and 117 mm, respectively.

Feed and nutrient intakes : Daily DM and nutrient intakes of the pullets are shown in Table 6. The DM, CP and ME intakes were 28% higher for the confined group (CF) compared to the control group (Cont) ($p<0.001$), but were not significantly different among scavenging treatments ($p>0.05$).

Daily weight gains, feed conversion ratios and feed costs : The average daily weight gain (ADG) was not significantly different between the CF and the Cont treatments, or among scavenging treatments ($p>0.05$) (Table 6). Replacement of SBM by CLM and FM with SBM did not adversely affect the growth performance of the

Table 6. Effect of age, scavenging and supplementation on dry matter (DM) and nutrient intakes and growth performance of improved pullets

Item	Mean, 4-20 weeks	Treatment				P value	SE
		Cont	CF	CLM	SBM		
Intake, g/day							
DM	64.3	55.8 [a]	77.5 [b]	63.3 [a]	61.6 [a]	***	3.12
CP	11.1	9.7 [a]	13.5 [b]	10.9 [a]	10.6 [a]	***	0.58
Lysine	0.47	0.43 [a]	0.59 [b]	0.33 [a]	0.52 [b]	***	0.03
Methionine	0.19	0.17 [a]	0.24 [b]	0.16 [a]	0.18 [a]	***	0.01
CF	1.54	0.99 [a]	1.38 [b]	2.70 [c]	1.27 [b]	***	0.08
Calcium	0.76	0.67 [a]	0.92 [b]	0.90 [b]	0.58 [a]	***	0.04
Phosphorus	0.53	0.49 [a]	0.67 [b]	0.53 [a]	0.45 [a]	***	0.03
ME (KJ)	902	795 [a]	1103 [b]	847 [a]	884 [a]	***	44.2
Initial live weight (g)	360	361	358	360	360		
Final live weight (g)	1,725	1,739	1,766	1,651	1,744		
ADG (g)	12.1	12.3	12.6	11.5	12.4	NS	2.29
FCR (kg feed DM / kg gain)	8.39	8.13 [a]	9.89 [a]	9.18 [a]	7.49 [a]	NS	3.91
Mortality (%)	7.03	6.25 [a]	9.37 [b]	6.25 [a]	6.25 [a]	*	0.42
Economic loss due to mortality (VND) [d]	67,500	60,000 [a]	90,000 [b]	60,000 [a]	60,000 [a]	*	4,050

*, ** and *** Significantly different at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.
[a, b, c] Means in the same row without a common superscript are significantly different. [d] 1 USD=15,000 VND.

Table 7. Effect of scavenging and supplementation on DM and nutrient intakes, and egg production and feed conversion (FCR) of improved laying hens

Item	Mean, 23-63 weeks	Treatment				P value	SE
		Cont	CF	CLM	SBM		
Intake, g/day							
DM	99.2	90.0 [a]	108 [c]	97.0 [b]	99.0 [b]	***	0.57
CP	18.6	17.0 [a]	20.8 [d]	17.8 [b]	19.2 [c]	***	0.11
Lysine	0.83	0.78 [a]	0.93 [c]	0.72 [b]	0.92 [c]	***	0.004
Methionine	0.34	0.31 [a]	0.37 [c]	0.34 [b]	0.34 [b]	***	0.002
CF	2.30	1.76 [a]	2.10 [b]	3.22 [c]	2.12 [b]	***	0.02
Calcium	2.17	1.97 [a]	2.36 [c]	2.14 [b]	2.17 [b]	***	0.01
Phosphorus	0.76	0.70 [a]	0.84 [c]	0.73 [b]	0.73 [b]	***	0.004
ME (KJ/d)	1,418	1,299 [a]	1,552 [d]	1,362 [b]	1,453 [c]	***	8.20
Initial live weight (g)	1,828	1,825	1,832	1,821	1,834		
Final live weight (g)	2,891	2,943	2,890	2,841	2,890		
Hen-day %	48.7	52.6 [a]	45.3 [b]	52.7 [a]	48.9 [ab]	***	1.35
FCR (kg feed DM/kg eggs)	4.33	3.57 [a]	5.24 [b]	3.88 [a]	4.46 [ab]	***	0.32
Feed cost/kg eggs (VND)	13,450	11,245 [a]	17,718 [b]	11,107 [a]	14,410 [ab]	***	808
Mortality (%)	7.3	12.5 [a]	0 [b]	8.3 [a]	8.3 [a]	***	0.05
Economic loss due to mortality (VND) [e]	105,000	180,000	0	120,000	120,000		

*, ** and *** Significantly different at $p<0.05$, $p<0.01$ and $p<0.001$, respectively.
[a-d] Means in the same row without a common superscript are significantly different. [e] 1 USD=15,000 VND.

scavenging pullets. The supplement feed cost per kg weight gain (FCS) for the Cont, CF, CLM and SBM treatments was 27,651 VND, 33,661 VND, 26,370 VND and 26,420 VND, respectively (1 USD=15,000 VND). FCS was thus around 25% higher for the CF compared to the Cont treatment ($p<0.05$), but there were no significant differences among scavenging treatments ($p>0.05$).

Mortality : The mortality was significantly higher for the confined than for the scavenging birds ($p<0.05$) and there were no significant differences among scavenging treatments ($p>0.05$). Assigning a current market value of 20,000 VND per bird, economic losses for the Cont, CF, CLM and SBM treatments were 60,000, 90,000, 60,000 and 60,000 VND, respectively (Table 6).

Experiment 2 (laying hens)

Climate data : Between November 2002 (the start of the layer experiment) and the end of April 2003 mean daily maximum temperatures ranged between 17.4 and 26.0°C and monthly rainfall between 10 and 23 mm. Between May and August 2003 mean daily maximum temperatures ranged between 28.1 and 30.0°C and monthly rainfall between 200 and 374 mm.

Feed and nutrient intakes : The DM, CP, ME, amino acid and macro-mineral intakes of the laying hens are shown in Table 7. DM intakes were around 20% higher for

Table 8. Effect of scavenging and supplementation on the egg quality of improved laying hens

Item	23-63 weeks of age	Treatment				P value	SE
		Cont	CF	CLM	SBM		
Egg weight (g)	58.8	58.8	57.9	58.7	59.5	NS	1.07
Shell thickness (mm)	0.38	0.38	0.38	0.37	0.38	NS	0.005
Shape index	1.39	1.38	1.39	1.39	1.38	NS	0.01
Shell wt (%)	10.1	10.4^a	9.3^b	10.4^a	10.4^a	***	0.15
Yolk wt (%)	29.2	29.1^a	27.6^b	29.9^a	29.9^a	***	0.51
Albumen wt (%)	61.2	60.9^a	63.1^a	60.9^a	60.0^b	**	0.84

*, ** and *** Significantly different at p<0.05, p<0.01 and p<0.001, respectively.

a,b Means in the same row without a common superscript are significantly different.

the CF compared to the Cont treatment, and around 10% higher than for the CLM and SBM treatments (p<0.001). Similarly CP, lysine, methionine, Ca, P and ME intakes were significantly higher (p<0.001) for the confined compared to the scavenging hens, and significantly higher for the CLM and SBM hens than for the Cont group (p<0.001). CP and lysine intakes were significantly higher (p<0.001) for the SBM treatment than for the CLM treatment.

Egg production, feed conversion ratios and feed costs : The effect of scavenging and protein supplement on egg production, egg weight, FCR and FCS are shown in Table 7. The hen-day production was significantly lower for the confinement treatment compared to the scavenging treatments (p<0.001). However, there were no significant differences among scavenging treatments (p>0.05). Egg weight was not significantly different between the CF and the Cont treatments, and among scavenging treatments (p>0.05). The supplement feed cost per kg eggs (FCS) for the Cont, CF, CLM and SBM treatments was 11,275 VND, 16,562 VND, 11,206 VND and 14,410 VND, respectively. The FCS was around 32% higher for the CF compared to the Cont treatment, although there were no significant differences among scavenging treatments (p>0.05).

Egg quality : The shell thickness, shape index and albumen content were not significantly different between the CF and Cont and other scavenging treatments (p>0.05) (Table 8). However, the shell and yolk percentages were significantly lower for the confined treatment compared to the control treatment (p<0.001).

Mortality : Mortality was significantly lower for the confined treatment compared to the scavenging treatments (p<0.001). However, there were no significant differences among scavenging treatments (p>0.05). Economic losses for the Cont, CF, CLM and SBM treatments were 180,000 VND, 0 VND, 120,000 VND and 120,000 VND, respectively (Table 7), and were significantly lower for the confined than the scavenging birds (p<0.001).

DISCUSSION

The protein in maize is of a poor nutritional quality, being deficient in both tryptophan and lysine (Smith, 1990), and therefore normally maize is combined with soybeans in poultry diets. Cassava leaf meal was found to be rich in all essential amino acids (Ravindran and Ravindran, 1988), but the CP content is very variable and depends on variety, stage of maturity, soil fertility and climate (Rogers and Milner, 1963; Phuc et al., 2000). The calcium content of CLM was quite high (10.9 g/kg), and Ravindran and Ravindran (1988) showed CLM to be a good source of most minerals, particularly trace minerals. The crude fiber (CF) content in the CLM used was 139 g/kg, which was about the same as the rice bran, although the fiber content of cassava leaves is quite variable, ranging from 97 to 146 g/kg, depending on maturity (Ravindran and Ravindran, 1988; Phuc et al., 2000). The content of HCN in the CLM (92 mg/kg DM) is considered safe for use as an animal feed, as the recommended safe limit of HCN in the diet is 50 mg HCN/kg (Bolhuis, 1954), a level which was not achieved in any of the diets tested, as the maximum level of inclusion of CLM was only 20% of the ration. The HCN content in the leaves was thus reduced by 75% by sun-drying for three days, which is in agreement with a study by Phuc et al. (2000) that found that 90% of the HCN in fresh cassava leaves was eliminated by two days of sun-drying.

Experiment 1 (pullets)

Feed and nutrient intakes : Dry matter intakes were around 28% higher for the confined group than for the scavenging birds given the same diet, which indicates that the pullets were probably getting at least 28% of their nutrient requirements from scavenging feed resources (SFR). The actual proportion from scavenging would have been even higher, as they would have required additional energy for scavenging activities. These results agree with an earlier choice feeding study carried out in Northern Vietnam that indicated that scavenging birds were probably getting between 22 and 32% of their nutrient requirements from SFR (Minh, 1999). However, the total intake of the scavenging birds was restricted by limited access to the supplement, which was not available during the day, whereas the confined birds had access to feed throughout the day and night. The proportion of the total diet from

scavenging was low compared with a report of Gunaratne et al. (1993), who found that scavenging village chickens in Sri Lanka were getting over 72% of their daily requirement from the SFR. Kitalyi (1998) concluded that 80 to 100% of the daily ration of scavenging local poultry in Africa is derived from SFR, but in this case the amounts of supplementary feed provided, and production would have been low. The scavenging feed resources base (SFRB) is highly variable and dependent on season, time of the grain sowing and harvest, insect life cycles, local farming systems, and the biomass of the village flock (Dessie and Ogle, 2001). As the start of the experiment coincided with the start of the hot, rainy season, this would have meant that insects, weeds, grasses, seeds, earthworms etc. were available in relatively large quantities, and the nutritive value of the young vegetative material would have been high.

Dry matter intakes were slightly higher for the CLM treatment than for the other scavenging treatments, which indicates that an inclusion level of 18-20% CLM in the diet DM did not reduce palatability. However this effect is dependent on the ingredients that are being replaced, and it was found that the growth depressing effects noted at higher levels of inclusion could be alleviated by supplemental methionine and energy (Montilla et al., 1976; Ravindran, 1993). Similarly, replacing FM by SBM did not have any adverse effects on DM and nutrient intakes. The total DM, CP and ME intakes were slightly higher for the CLM treatment compared to the Cont and the other scavenging treatments, probably because of the lower ME content of the CLM diet.

Daily weight gains, feed conversion ratios and feed costs : Live weight gains were similar among treatment groups, in spite of lower intakes of CP, lysine and methionine in all scavenging treatments compared to the confined group. This indicates that scavenging birds can meet their nutrient requirements from SFR for normal growth provided that they are given access to a balanced supplement in the evenings. This is supported by a study on the crop contents of scavenging chickens in Tanzania (Mwalusanya et al., 2002), which showed that their nutrient status, in particular with respect to protein intake, was below the requirements for optimum growth, and concluded that a balanced supplement is necessary. Data on the effects of replacing FM with SBM in supplements for scavenging poultry are not available in Vietnam. However, although the protein quality of SBM is inferior to that of FM, particularly with respect to the content of methionine and cystine, this did not result in any problems for the scavenging birds, as they were obviously able to improve the overall amino acid balance of their diet by eating high quality protein sources such as insects and earthworms. Similarly, inclusion of 20% CLM in the supplement did not result in lower gains, in spite of the fact that lysine intake was significantly lower compared to the SBM treatment.

Mortality : The probable explanation for the higher mortality of the confined group compared to all scavenging groups is that the confined birds were affected by heat stress, as the mean daily maximum temperature for the four months of the experiment was around 30°C, and humidity around 80%. The main causes of death were probably heat stress and feather pecking, and isolated incidences of feather pecking in all treatment groups were observed when the pullets were about 17 weeks of age, although the reason for this is not known.

Experiment 2 (laying hens)

Feed and nutrient intakes : The 20% higher DM intake of the CF compared to the Cont group indicates that the scavenging layers were probably getting at least 20% of their nutrient requirements from SFR. They would in fact have required additional energy for scavenging activities, so the contribution of scavenging to overall intake would have been even higher. These results agree with an earlier choice feeding study carried out in Northern Vietnam, that indicated that scavenging layers were probably getting around 22% their requirements from SFR (Minh, 1999). The pullets got around 28% of their nutrient requirements from SFR, which is a higher proportion than for the layers, probably as a result of the higher nutrient requirements of layers and the fact that the hens spent time in laying activities, reducing time available for scavenging. Also the SFR for the hens could have been limited, as the amounts of insects, worms and green plant material were lower in the dry, cool, autumn and winter seasons. The mean monthly rainfall between November and April ranged between 10 and 23 mm, and there were very few insects and very little fresh, green vegetation for the birds to eat. The ME intake of the confined layers agreed fairly well with feeding standards suggested by Daghir (1995), who calculated the ME requirement of laying hens to be 1,520 KJ per day for a hen weighting 2.0 kg, and that they required 15 g CP daily to ensure a reasonable level of egg production in hot climates. In our study mean daily ME intake of the confined birds was 1,552 KJ, but CP intake was much higher, at 20.8 g CP per day. NRC (1994) estimated the daily protein requirement for egg laying hens to be between 16 and 17 g per hen per day. However, the birds in our study were a dual-purpose breed and therefore their CP requirement was not only to meet the demand for egg production but also for tissue growth, and the mean body weight in fact increased by over 1,000 g during the 40 weeks of lay.

The DM, CP and ME intakes were significantly different between scavenging treatments, and the replacement of SBM with CLM, and FM with SBM, increased the feed intake compared to the control diet,

which indicates that an inclusion level of 20% CLM did not result in reduced palatability. That the DMI was higher for the CLM than the Cont diet could have been due to the higher crude fibre content of CLM and resulting lower diet digestibility and ME content, which would have increased feed intake, although mean daily ME intake was still lower than for the Cont treatment.

Egg production, feed conversion ratios and feed costs : The lower egg production of the confined layers could have been due to a nutrient deficiency or amino acid imbalance in the basal concentrate for optimum egg production. Layers on the scavenging treatments would probably have been able to correct any amino acid imbalances, and/or mineral, and vitamin deficiencies in the supplementary feed from scavenged feed resources. Another explanation for the lower production of the confined layers could have been heat stress, as daytime temperatures were probably higher in the poultry house. The high production performance of all scavenging groups also indicates that CLM can be included in supplements up to a level of 20% and that FM can be replaced by SBM in scavenging laying diets with no adverse effects on egg production. Egg weight increased with age, whereas hen-day production decreased. This is in agreement with the normal development of laying physiology, and the values compare fairly well with a report of Dat et al. (2001) from an investigation of the biological characteristics and production performance of Luong Phuong chickens in confinement, in which egg production decreased from 58.5% to 49.5% from 43 to 66 weeks of age, respectively.

Egg quality : A possible explanation for the lower shell and yolk percentages for the confined hens could have been a slight calcium and/or other mineral deficiency in the concentrate, which the scavenging hens were able to compensate for from SFR. It is also possible that heat stress contributed to the lower shell weight of the confined hens. These findings are in agreement with Devegowda (1992), who reported that in India, separate calcium feeding along with reducing the calcium level in the diet to about 2% improved feed intake and increased egg production and shell quality. The result also indicates that replacing SBM with CLM, and FM with SBM did not adversely affect the egg quality of scavenging improved laying hens.

Mortality and economic losses : The higher mortality of the scavenging hens compared to the confined group was probably due to the increased exposure to disease vectors and parasitic infestation over a long period of time. This is in agreement with a study of Dana and Ogle (2002) in Ethiopia that concluded that higher mortality occurred in scavenging hens than in confined hens. Mortalities in the scavenging hens were mainly a result of reproductive disorders, and internal bleeding was observed in several cases. The market value of a laying hen in Vietnam is around 60,000 VND, which would imply economic losses amounting to around 180,000 VND on the Cont treatment, and 120,000 VND for the CLM and SBM treatments. However, a mean mortality of around 10% over the whole laying period would be considered to be very low for scavenging hens, and it was calculated that the saving on feed costs of around 53,000 VND per bird for the most economical scavenging treatment (CLM) compared to the confined treatment, would have easily outweighed the economic loss due to mortalities (around 5,000 VND per hen housed).

CONCLUSIONS

It can be concluded from the two experiments that scavenging pullets and laying hens were probably getting around 28% and 22%, respectively, of their nutrient requirements from scavenging activities. This, and the use of less expensive protein supplements, resulted in increased net economic benefits of between 18 and 32% compared to confinement. Confinement had no effect on the daily gains of the pullets, although mortality rates were higher compared to scavenging. Egg production and mortality rates were lower for the confined hens compared to the scavenging hens. Replacing the soybean meal in the supplementary diet by cassava leaf meal, and the fishmeal by soybean meal, did not affect the production performance of the scavenging pullets and laying hens, and increased net economic benefits.

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