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Performance of Layers Supplemented with Either Complete Feed or Diets in Cafeteria Feeding System Under Semi–scavenging Condition in a Tropical Environment

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1. Egg production ability and its economical aspect were compared among the hens kept under semi–scavenging condition on two feeding systems with four supplementary levels. Commercial balanced feed and cafeteria feeding diet were fed the hens at 40 g, 60 g, 80 g and 120 g/day respectively. Cafeteria feeding diet was composed of 70% mixed feed (40% broken rice, 20% rice polish and 10% wheat bran), 27% soybean meal and 3% oyster shell.
2. The mean feed residue was 4–8 g/day in the hens fed 40 g and 60 g feed group and in 120 g feed group of both feeding system was about 20 g. Body weight gain in the experimental period markedly varied but did not differ among the feed groups.
3. Hen day egg production was highest in the 120 g commercial feed group (55%), followed by the 120 g cafeteria feeding group (45%) and the 80 g commercial feed group (42%). The other feed groups showed 34–37% in hen day egg production except for 27% of the 40 g commercial feed group. Egg quality did not have an intimate relation with the different feed regimes.
4. Regardless of the low egg production ability, the 40 g cafeteria feeding group produced the highest net profit and the 80 g cafeteria feeding group produced the second highest profit. These high net profits were brought from low feed cost. However, the highest income was observed in the 120 g commercial feed group.
5. From these results, it was suggested that under semi–scavenging condition supplemented feeds improve the egg production ability of hens in parallel with the feeding volume although large volume diet decrease large profit.

INTRODUCTION

Today complete feed predominates because it is easier to manage in the prevalent cage housing and automated feeding systems (Blair *et al*., 1973; Karunnajeewa, 1978a; Leeson and Summers, 1979). In practice, nearly all diets for laying hens are given as mash; this simplifies feeding and is widely believed to assure a better balance of nutrients (Stadelman, 1995). However, offering free choice diets allow individual opportunity to select the feed needed for maintenance and production and may increase efficiency over that when fed a single diet (Emmans, 1978; Robinson, 1985). The energy costs of grinding and mixing could be saved if poultry could utilize whole grains and choose individual dietary components (Karunajeewa, 1978b; Karunajeewa and Tham, 1984; Tauson *et al*., 1991), such that the efficiency of feed utilization is improved (Blair *et al*., 1973; Karunajeewa, 1978a; Cumming, 1984; Henuk *et al*., 2000a).

Choice feeding of layers has financial advantages for rural small–scale poultry production in developing countries where the transport cost of feedstuffs is high and diet–mixing machinery is expensive (Cumming, 1992; Ciszuk *et al*., 1998). Locally producing ingredients such as maize, wheat, sorghum etc could be utilized far more efficiently if fed in a free choice feeding system than as a complete diet. The hens fed with either a complete layer mash or a choice between the complete diet and ground barley could not show significant difference in performance (Emmans, 1977) and the hens received a choice between the whole grains and a concentrate mixture lay heavier eggs and consumes 11% less feed than those given the complete diets (Karunajeewa, 1978a). The effect of choice feeding is also observed on the performance of growing and laying pullets (Olver and Malan, 2000). In terms of feed utilization efficiency, cafeteria system has been reported to be superior (Olver and Malan, 2000), similar (Dana and Ogle, 2002) or inferior (McDonald and Emmans, 1980) compared with complete diet system.

This study was carried out to assess the effect of semi–scavenging on diet selection for development of an appropriate supplementation strategy in the hens of rural farmers. Cafeteria feeding system and commercial

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balanced diet feeding was compared on the performance of hens.

MATERIALS AND METHODS

Experimental hens and Housing

This experiment was carried out during 15 weeks period including 2 weeks adaptation in rainy season using farmer's homesteads in the southern part of Bangladesh. Farmers were selected on the basis of sincerity and interest in the present work and were given a training program about poultry husbandry.

Hens of 33 weeks old were used and the 120 chickens were divided into 8 dietary treatment groups with 3 subgroups in each. Each treatment group was composed of 15 birds and each subgroup of 5 birds was reared by each farmer. The hens of each group were supplemented with 40 g, 60 g, 80 g and 120 g of either the commercial balanced feed or the cafeteria feeding diets respectively under semi–scavenging condition. In the cafeteria feeding system, mixed feed as energy source, soybean meal and oyster shell were given by separate compartments of the feeder. Clean water was provided *ad libitum* throughout the experimental period.

The day shelter ($1.2\times0.7\,m^2$, $0.17\,m^2$ per hen) was constructed with bamboo, wood and straw, and was equipped with a bamboo feeder with three compartments and a plastic water container. Then, a perch of bamboo and one round laying nest made by mud was set inside the house. However, the night shelter basket was kept inside farmer's house.

Feeds

The commercial balanced feed (layer feed in pellet) and individual feed ingredients for cafeteria feeding such as broken rice, rice polish, wheat bran, soybean meal and oyster shell were purchased in local market. The cafeteria feeding diets were prepared in the following composition; energy source feeds (total 70%, mixed feed of 40% broken rice, 20% rice polish and 10% wheat bran), protein source ingredient (27%, soybean meal) and calcium source ingredient (3%, oyster shell). Samples of these feeds were analyzed in the Department of Livestock Services (Dhaka, Bangladesh) for determination of metabolizable energy (ME), dry matter (DM), crude protein (CP), crude fat (CF), ether extract (EE), and ash according to the procedures of AOAC (1990). The detailed results of the analysis are shown in Table 1.

Production performance

Quantitative and qualitative traits of egg production were observed using the hens of 35 to 47 weeks old. Body weight was measured weekly and feed residue (wastage and leftover) was recorded monthly. Egg was observed daily and hen day egg production (%) was calculated from the total number of eggs and the total days of hens alive in each of the subgroups throughout the period (North and Bell, 1990). Average egg mass (g) per hen per day was calculated by multiplying percentage of hen day egg production with average egg weight (g). Mortality was recorded.

Two eggs per week were selected at random in each group and supplied for measuring egg weight, shell weight and thickness, albumin height, and yolk height and diameter. Haugh unit (HU) and yolk index were calculated with the formulas of Haugh (1937) and Wesley and Stadelman (1959) respectively. Yolk color was determined with Roche yolk color fan (RYC, F. Hoffman–Ia Roche and Ltd., Switzerland) (Vuilleumier, 1969).

Experimental design and statistical analysis

Data of factor one; feeding systems (complete diet feeding and cafeteria feeding) and factor two; supplementary levels of feed volume (40, 60, 80 and 120 g/ day/ hen) were arranged and compared with two–way ANOVA. However, as no significant difference between the feeding systems and no interaction between the feeding systems and levels were observed except for yolk color index, data were compared with one–way ANOVA, followed by Duncan's multiple range test. A probability of $p<0.05$ was considered to show significant differences.

RESULTS

Body weight and egg production ability

As laying hen usually intakes 100 g or more diet per day, the 40 g, 60 g and 80 g supplemented feeds are not enough for chicken to produce egg, and they must scavenge much diet by themselves in the farmstead. The supplemented feed was remained by 4–5 g in the 40 g

Table 1. Chemical composition of the commercial balanced feed and ingredients for cafeteria feeding

Components	ME* (MJ/kg)	DM (%)	CP (%)	CF (%)	EE (%)	NFE **(%)	Ash (%)
Commercial balanced	13.75	90.77	18.16	4.1	5.53	68.71	3.5
Cafeteria feeding							
Mixed feed***	15.43	86.62	12.22	4.25	5.74	77.66	0.13
Soybean meal	10.62	87.41	46.43	7.46	1.49	44.27	0.35
Oyster shell	–	–	–	–	–	–	29.65

Abbreviation of components are; ME; metabolizable energy, DM; dry matter, CP; crude protein, CF; crude fiber, EE; ether extract, and NFE; nitrogen-free extract

* ME (kcal/ kg dry matter) = 3951 + 54.4EE − 88.7CF − 40.8Ash

**NFE (%) = 100 − %(CP + EE + CF + Ash)

*** Mixed feed contains broken rice, rice polish and wheat bran at the ratio of 4:2:1.

groups, 6–8 g in the 60 g groups, and 8–13 g in the 80 g groups. On the other hand, the 120 g chicken groups remained much feed of 19–22 g and seemed to be satisfied mostly by the supplemented feed (Table 2). Although the 80 g and 120 g groups of the commercial feed had lost one hen in each by predator, it did not seem that their mortality had a relation with the feed and feeding system because of the good ability of egg production shown by the remainder hens.

Initial body weight at 34 weeks of age varied markedly among the bird groups, where the largest weight 1490 g in the 40 g commercial feed group was much larger by 200 g from the smallest weight in the 60 g cafeteria feeding group (Table 2). The body weight gain during the experimental period did not differ significantly among the bird groups regardless of the wide range from −118 g to 19 g.

The bird group fed more feed showed the better ability in hen day egg production in each feed system (Table 2). Of the commercial feed groups the best ability in hen day egg production was shown by the 120 g group (55%) followed by the 80 g group (42%), and also in the cafeteria feeding groups the best ability was indicated by the 120 g group (45%) followed by the 80 g group (37%). In hen day egg production, the 120 g commercial feed group exhibited rather better ability than the 120 g cafeteria feeding group although significant difference could not observed between them because of wide standard error in the latter. Egg mass (g/hen/day) was largest in the 120 g commercial feed group, followed by the 120 g cafeteria feeding and the 80 g commercial feed groups, and the smallest egg mass was shown by the other chicken groups.

Egg quality

The bird groups fed a small volume of the feed, especially the 40 g or 60 g group have to take up a half or more diet from various feed stuffs such as grains, seeds, grasses and worms in the farmstead. Then the consumed feed stuffs are able to affect an essential effect on the egg external and internal quality. However, mean egg weight was almost 43 g or 44 g except for 45 g in the 60 g cafeteria feeding group and 46 g in the 40 g commercial feed group of which the latter was lowest in hen day egg production and also the former was low. The mean weights indicated that the greater part of the eggs are categorized into very small (SS, 40–46 g) class or small (S, 46–52 g) class.

The effect of the commercial feed and cafeteria feeding diets on egg quality should appear markedly in each 120 g group. While shape index was larger in the 120 g commercial feed group and conversely yolk color score was higher in the 120 g cafeteria feeding group, the other factors such as egg weight, shell percentage and thickness, yolk index and Haugh unit did not differ between them (Table 3). Yolk index decreased by only a little from 0.44 at oviposition but was good in all bird groups. Haugh unit indicated the best AA class (over

Table 2. Comparison of feed residue, body weight change and egg production index among the bird group

Treatments	Commercial balanced feed				Cafeteria feeding feed			
Supplemented feed (g/hen)	40	60	80	120	40	60	80	120
Feed residue (g/day)	4±0.3d	6±0.7c	8±0.8c	22±7.5abc	5±0.8cd	8±1.4c	13±0.4b	19±1.0a
No. of alive hens*	15	15	14	14	15	15	15	15
Initial body weight (g) **	1490±36a	1320±43bc	1430±31ab	1440±50ab	1370±48bc	1290±49c	1410±63ab	1350±27bc
Body weight gain (g/hen)**	−86±69a	−117±57a	−46±60a	−3±63a	−9±83a	19±44a	−118±104a	18±43a
Hen day egg production (%)	27±3.2c	34±7.9bc	42±9.1abc	55±2.4a	33±2.6bc	33±8.0bc	37±5.2bc	45±7.4ab
Egg mass (g/hen/day)	12±1.6b	14±3.5b	18±3.9ab	24±0.5a	14±1.2b	15±3.7b	16±1.7b	19±3.2ab

Mean±standard error
* Initial number of hens in each group is 15. ** Initial body weight at 34 weeks of age and body weight gain throughout the experimental period.
a,b,c, d Means with the same letter within raw do not differ significantly at 5% level.

Table 3. Comparison of external and internal egg qualities among the hen groups

Treatments	Commercial balanced feed				Cafeteria feeding feed			
Supplemented feed (g/hen)	40	60	80	120	40	60	80	120
External quality								
Egg weight (g)	46±0.4a	43±0.6b	44±1.5ab	44±1.1ab	43±0.4b	45±0.9ab	43±2.0b	44±0.8ab
Shape index	78±1.6ab	77±3.2 bc	77±2.2bc	79±0.6a	77±0.8bc	78±0.8ab	79±1.3a	76±0.8c
Shell percentage	8.8±0.1ab	8.9±0.3ab	8.3±0.3b	8.9±0.3ab	8.5±0.5ab	8.3±0.2b	9.1±0.5a	8.7±0.3ab
Shell thickness (mm)	0.31±0.01ab	0.30±0.01b	0.30±0.00b	0.32±0.01a	0.31±0.01ab	0.31±0.01ab	0.32±0.01a	0.31±0.00ab
Internal quality								
Yolk index	0.40±0.01a	0.40±0.01a	0.39±0.01a	0.39±0.01a	0.40±0.01a	0.38±0.01a	0.40±0.01a	0.40±0.02a
Haugh unit	67±8.0b	69±2.0b	73±2.2ab	73±2.3ab	73±0.6ab	76±2.1ab	80±3.5a	73±2.3ab
Yolk color score	8±0.7b	10±1.2a	7±0.4b	7±0.6b	9±0.6a	9±0.0a	10±0.0a	9±0.00a

Mean±standard error (n = 26)
a,b,c Means with the same letter within raw do not differ significantly at 5% level.

Table 4. Comparison of total income, total expenditure and net profit per year in USD among the chicken groups

Treatments	Commercial balanced feed				Cafeteria feeding feed			
Supplemented feed (g)	40	60	80	120	40	60	80	120
Total Income	7.65	9.15	10.89	13.77	8.97	8.97	9.81	11.55
Egg number (/hen/year)*	99	124	153	201	121	121	135	164
Total egg price**	5.94	7.44	9.18	12.06	7.26	7.26	8.10	9.84
Spent hen price	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71
Total Expenditure	5.94	7.46	9.08	12.11	5.63	6.93	8.13	10.89
Pullet cost (/hen)	2.57	2.57	2.57	2.57	2.57	2.57	2.57	2.57
Feed cost (/hen/year)	3.03	4.54	6.04	9.07	2.71	4.01	5.21	7.97
Medical cost	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Mortality cost (/hen)	0	0	0.12	0.12	0	0	0	0
Net Profit	1.71	1.69	1.81	1.66	3.34	2.04	1.68	0.66

* Hen day egg production (%)×365, ** 0.06USD/egg

72) egg produced by the other bird groups except for the 40 g and 60 g commercial feed groups producing the second A class (72–60) egg. In yolk color score, the other commercial feed groups except for the 60 g group showed lower value compared with all groups of the cafeteria feeding. From these results, it was not comprehend that items of egg quality except for yolk color score had an intimate relation with the feed types and feeding regimes. The hens could produce eggs with fairly even quality regardless of their different abilities of hen day egg production and their various feed regimes.

Economic aspects

Because of the best ability of egg production, in the 120 g commercial feed group the highest yearly income was guaranteed but the net profit was compressed by the high cost of the commercial balanced feed (Table 4). Of the commercial feed groups, the 80 g group brought the highest net profit from economy in the feed expenditure rather than the 120 g group. Although the ingredients for cafeteria feeding was cheaper than the commercial feed, the 120 g and 80 g cafeteria feeding groups could not make the net profit increase by less income of the produced egg relative to the feed cost. The most net profit was obtained in the 40 g cafeteria feeding group showing most economy in feed expenditure, followed by the 60 g cafeteria feeding group. Every commercial feed group produced fairly constant net profit independent of various numbers of eggs and different feeding volumes. On the other hand, in the cafeteria feeding system the egg production ability of hens was improved more slowly with increasing volume of diet and the net profit was least in the 120 g feeding group.

DISCUSSION

Under semi–scavenging feeding, the various types and volume of feeds found surround the farmstead could markedly vary depending on the farmer's condition. For this reason the body weight gain of hens is low or negative regardless of supplemented feed volume (Ali, 2002) and feed type (Cowan and Michie, 1979; Kiiskinen, 1987; Farrell *et al.*, 1981). In the present study, the body weight gain in the experimental period of 13 weeks markedly differed among the chicken groups within the wide range of −118 g to 19 g but did not differ significantly among the bird groups because of the large individual variation. The body weight in the 80 g cafeteria feeding group and the 60 g commercial feed group markedly decreased while the 40 g and 60 g cafeteria feeding groups showed better weight gain. As the former groups were fed more supplemented feeds rather than the latter groups, the different body weight gain could be based mainly on the quantitative and qualitative difference of scavenging feeds. The 120 g bird groups in both feeding systems had maintained the mean body weight at same level during the experimental period but exhibited considerable individual variation of the body weight gain.

The feed stuffs scavenged by hens in farmstead are essential factor affecting the egg production, especially in the bird group fed less supplemented diets. In the present study, the scavenging feed was not enough for chickens to demonstrate the full ability of egg production because of the lower egg production in the hens supplemented less feed. Rahman *et al.* (1998) observed 55% in hen day egg production by supplementing 120 g of balanced feed and 36% with 75 g supplementation in the 52 weeks experimental period. Moreover, the similar relationship between the supplemented feed volume and the performance of egg production has been reported also by Islam *et al.* (1992) and Ali (2002). From these results, it was indicated that the feed intake from edible resources in the farmstead either cannot cover the shortage of supplemented feed or nutrients for egg production. Only by feeding 120 g commercial balanced feed could affect an essential effect on the hens' ability of egg production compared with the cafeteria feeding diets. In the less volume, especially in 40 g and 60 g, the commercial feed did not showed any difference in the hens' ability from the cafeteria feeding diets.

In the present study, supplemented feed level did not seem to have a relation to the egg weight although Rahman *et al.* (1998) and Ali (2002) have reported the positive interrelation between them. Under semi–scavenging feeding, although calcium intake may be limited in the hens by feeding less supplemented feed, the shell quality indexes were acceptable. As young hens can use calcium mobilized from the medullary bone for organizing shell, calcium defect syndrome did not appear in the hens of 35 to 47 weeks old in the present study. Rashid (2003) measured wet shell at 10.1–10.4% of egg weight after removing shell membrane. In the present study, the shell was weighed at slightly smaller percentage because shell was dried out after removing membrane. High yolk color score is recorded in the egg produced by the hens fed in free range system (Pavlovski *et al.*, 1981, 1994), fed 6–7 g grass meal (Taplin *et al.*, 1983; Smith, 1996) or fed yellow maize (Olver and Malan, 2000). In this study, the yolk color score was affected by the feed types and increased by the cafeteria feeding diets. The diets found around the farmstead may also make the color score increase in the 60 g commercial feed group. Although yolk index indicated the good quality of egg in all bird groups, the Haugh unit of the 40 g and 60 g commercial feed groups was scored at the second best A class. Moreover, the best score in Haugh unit was recognized in the 80 g cafeteria feeding group rather than the 120 g group. From these results it was suggested that in this study the farm's condition could be rather essential factor than the volume and type of the supplemented feeds.

While complete balanced feed needs its processing cost at approximately 10% to 15% of the feed price (Cumming, 1992; Cheeke, 1999), the commercial balanced feed was estimated to increase the yearly income from egg production by 18.4% and 11.2% by feeding 120 g and 80 g respectively compared with each counterpart of the cafeteria feeding group. Although the net profit was calculated to be highest in the 40 g cafeteria feeding group, followed by the 60 g cafeteria group, the estimation was based on the results of short term experiment of 13 weeks (1/4 year). The net profit should be changed by an elongation of the feeding period and various environmental and social factors. Then it seems to be rather important that under semi–scavenging condition a complete balanced feed can improve the egg production ability of hen by feeding enough volume of the feed at least 80 g to 120 g.

In conclusion, under semi–scavenging condition in a tropical country the commercial balanced feed could markedly improve the egg production when enough volume (120 g or 80 g) of the feed was supplemented. However, the balanced feed did not always bring large profit because of its high price. On the other hand, although the cafeteria feeding diet was cheaper, it could not counterbalance the feed cost by improving the egg production with increasing the feeding volume and brought the highest profit by feeding at the least supplemented level (40 g).

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