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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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Institutes 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 commercial complete diet system.

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 feed predominates because it is easier to manage in the prevalent cage housing and automated feeding systems (Blair et al., 1973; Karunajeewa, 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).

INTRODUCTION

Today complete feed predominates because it is easier to manage in the prevalent cage housing and automated feeding systems (Blair et al., 1973; Karunajeewa, 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
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 (1.2×0.7 m², 0.17 m² 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. In 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-La 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

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**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
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 (45%) followed by the 80 g group (55%) followed by the 80 g group (42%), and also the effect of the commercial feed 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 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.

**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 90). Egg quality

**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 | 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±0.8c 4±1.4c 14±3.6b 19±1.0a  | 14±3.6b 19±1.0a  |
| No. of alive hens*          | 15  15  14  15  15  15  15  15  | 15  15  15  15  15  15  15  15  |
| Initial body weight (g) **  | 1490±36a 1320±43bc 1430±31abc 1440±50abc 1370±48bc 1290±49c 1410±63ab 1350±27bc  | 1410±63ab 1350±27bc  |
| Body weight gain (g/hen)**  | –86±69a –117±57a –46±69a –3±63a –9±83a 19±44a –118±104a 18±43a  | 19±44a –118±104a 18±43a  |
| Hen day egg production (%)  | 27±3.2c 34±7.9b 42.9±1abc 55±2.4a 33±2.6b 37±5.2bc 45±7.4ab  | 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  | 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 | 40  60  80  120  40  60  80  120 |
| Egg weight (g)              | 46±0.4a 42±0.6b 44±1.5ab 44±1.1ab 43±0.4b 45±0.9b 43±2.0b 44±0.8ab  | 44±0.8ab  |
| Shape index                 | 78±1.6ab 77±2.2bc 77±2.2bc 79±0.6a 77±0.8bc 78±0.8a 79±1.3a 76±0.8c  | 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  | 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 0.32±0.01a 0.32±0.01a 0.31±0.00ab  | 0.31±0.00ab  |
| 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  | 0.40±0.02a  |
| Haugh unit                  | 47±8.9b 69±2.9b 73±2.2ab 73±2.3ab 73±0.6ab 76±2.1ab 80±5.5a 73±2.3ab  | 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  | 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.
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 feed type (Cowan and Michie, 1979; Kiiskinen, 1987; Islam et al., 1998)积肥程度。因此，农场周围的环境会根据农场的条件而变化。因此，养鸡者体重的增重较低或为负数，无论是否补充饲料体积（Ali，2002）和饲料类型（Cowan和Michie，1979；Kiiskinen，1987；Farrell等人，1981）。在本研究中，养鸡者在13周实验期内的体重增重因不同类型的饲料和饲养方法而显著不同。

讨论

在半 scavenging 饲养下，不同类型的饲料和饲料体积会显著地影响养鸡者的体重增重。对于这个问题，体重增重的养鸡者体重较低或为负数，无论是否补充饲料体积（Ali，2002）和饲料类型（Cowan和Michie，1979；Kiiskinen，1987；Farrell等人，1981）。在本研究中，养鸡者在13周实验期内的体重增重因不同类型的饲料和饲养方法而显著不同。
ing 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).

REFERENCES

ALI, S. 2002 Study on the effect of feed supplementation to laying hen under the rural condition of Bangladesh. MSc thesis. Department of Animal Science and Animal Health and Network for Smallholder Poultry Development, The Royal Veterinary and Agricultural University, Dyrægevej, 1870 Frederiksborg C, Denmark

AOAC 1990 (Association of Official Analytical Chemists) Official Methods of Analysis. 15th ed. AOAC, Arlington, VA, USA, 1298 pp.

BLAIR, R., DEWAR, W. A. & DOWNIE, J. N. 1973 Egg production responses of hens given a complete mash or unground grain together with concentrate pellets. British poultry science, 14: 373–377

CHEEKE, P. R. 1999 Applied Animal Nutrition– Feed and Feeding. 2nd Edition. Macmillan Publishing Company, New York

CISZUK, P., CHARPENTIER, L. & HULT, E., 1998 Free choice of feed for ecological hens. FAKTA, Jordbruk, aktuell forskning vid SLU, Nr. 7

COWAN, P. J. & MICHE, W. 1979 Choice feeding of food during rearing and lay. World Review of Animal Production, Vol. XV, No. 3, July–September

CUMMING, R. B. 1992 The advantages of free choice feeding for village chickens. Proceedings of the 19th World’s Poultry Congress, pp. 827

CUMMING, R. B. 1984 Choice feeding of laying hens. Proceedings of the Poultry Husbandry Research Foundation Symposium. University of Sydney, NSW, Australia, pp. 68–71

DANA, N. & OGLE, B. 2002 Effects of scavenging on diet selection and performance of Rhode Island Red and Fayoumi breeds, of chicken offered a choice of energy and protein feeds. Tropical Animal Health and Production, 34: 417–429

EMMANS, G. C. 1977 The nutrient intake of laying hens given a choice of diets, in relation to their production requirements. British Poultry Science, 18: 227–236

EMMANS, G. C. 1978 Free choice feeding of laying poultry. Pages 31–39 in: Recent Advances in Animal Nutrition. W. Haresign and D.Lewis, ed. Butterworths, London, Uk

FARRELL, D. J., RAMLAH, H. & HUTAGALUNG, R. I. 1981 Free–choice feeding of laying hens in the humid tropics. Tropical Animal Production, 6: 22–29

HAUGH, R. R. 1937 The Haugh unit for measuring egg quality. U.S. Egg Poultry Magazine, 43: 552–553 and 572–573

HENKX, V. L., THWAITES, C. J., HILL, M. K. & DINGLE, J. G. 2000 The effect of temperature on responses of laying hens to choice feeding in a single feeder. In: Proceedings of the Australian Poultry Science Symposium (Pym, R. A. E., Ed.), University of Sydney, Sydney, pp. 117–120

ISLAM, M. K., HUSSAIN, M. A., HAQUE, M. F. & PAUL, D. C. 1992 Performance of Fayoumi poultry breed with supplementary ration under farmer’s management. Proceeding of the Fourth National Conference of Bangladesh Animal Husbandry Association, Bangladesh Agricultural Research Council, Dhaka, pp. 20–29

KARUNAJEEWA, H. 1978a The performance of Cross–bred hens given free choice feeding of whole grains and a concentrate mixture and the influence of source of xanthophylls on yolk color. British Poultry Science, 19: 699–708

KARUNAJEEWA, H. 1978b Free–choice of poultry: a review. In: Recent Advances in Animal Nutrition 1978 (Farrell, D. J., Ed.), University of New England Printing Unit, Armidale, pp. 57–70

KARUNAJEEWA, H. & THAM, S. H. 1984 Choice feeding of the replacement pullet on whole grains and subsequent performance on laying diets. British poultry Science, 25: 99–109

KIISKINEN, T. 1987 Influence of choice feeding on the performance and the influence of source of xanthophylls on yolk color. British Poultry Science, 26: 131–144

LEESEN, S. & SUMMERS, J. D. 1979 Dietary self–selection by layers. Poultry Science, 58: 646–651

McDONALD, R. & EMMANS, G. C. 1980 Choice feeding of turkey breeder hens in single cages. World’s Poultry Science Journal, 36: 68–73

NORTH, M. O. & BELL, D. D. 1990 Commercial chicken production manual, 4th edition. Chapman & Hall, New York

OLVER, M. D. & MALAN, D. D. 2000 The effect of choice–feeding from 7 weeks of age on the production characteristics of laying hens. South African Journal of Animal science, 30: 110–114

PAVLOVSKI, Z., BASIC, B. & APOSTLOV, N. 1981 Quality of eggs laid by hens kept on free range and in cages. In: Quality
of eggs, proceedings of first European Symposium by World Poultry science Association, European Federation, pp. 231–235

PAVLOVSÍK, Z., HOPIC, B., VRACAR, S. & MASIĆ, B. 1994 The effect of housing system on internal egg quality traits in small layer flocks. Biotehnologija u stocarstvu (Yugoslavija), 10: 37– 43

RAHMAN, M., ISLAM, M., SARKER, N. R. & ISLAM, M. M. 1998 Effect of Supplementary feeding on production performance of RIR, Fayoumi and their Cross bred chicken in rural Bangladesh. Bangladesh Journal of Livestock Research, 1: 184–193

RASHID, M. M. M. 2003 Nutritional Status of Scavenging Chickens with special emphasis on Energy and Protein Supplementation under Rural Conditions in Bangladesh. M.Sc thesis. Department of Animal Science and Animal Health and Network for Smallholder Poultry Development, The Royal Veterinary and Agricultural University, Dyrægevej, 1870 Frederiksberg C., Denmark

ROBINSON, D. 1985 Performance of laying hens as affected by split time and split composition dietary regimens using ground and unground cereals. British Poultry Science, 26: 299–309

SMITH, A. J. 1996 Poultry. Macmillan Education Ltd, London and Oxford. pp. 130

STADELMEN, W. J. 1995 Egg production practices, In: egg science and technology, 4th edition (Stadelmen, W. J. and Cotterill, O. J. Eds), Food Press Products, New York, pp. 9–37

TAUSON, R., JANSSON, L. & ELWINGER, K. 1991 Whole grain/ crushed peas and concentrate in mechanized choice feeding for caged laying hens. Acta Agriculture Scandinavica, 41: 75–83

TAPLIN, D. E., D'MELLO, J. P. F. & PHILLIPS, P. 1983 Evaluation of Leucaena leaf meal from Malawi as a source of xanthophylls for the laying hen. Tropical Science, 23: 217–226

VUILLEUMIER, J. P. 1969 The “Roche Yolk Color Fan”. An instrument for measuring yolk color. Poultry Science, 48: 767–779

WESLEY, R. L & STADELMAN, W. J. 1959 Measurement of interior egg quality. Poultry Science, 38: 79–481