Effects of diet composition on the energy balance of free-ranging organic broilers

F B Realon-Garcia¹,²* and E A Lantinga²*

¹Department of Agriculture-Bureau of Animal Industry, National Swine and Poultry Research and Development Center, Visayas Avenue, Diliman Quezon City, Philippines
²Farming Systems Ecology Group, Wageningen University, Droevendaalsesteeg 1, 6708PB Wageningen, the Netherlands
*Email: fe_bien_r_garcia@yahoo.com.ph and egbert.lantinga@wur.nl

Abstract. In organic broiler production, one big factor in meeting the energy requirements of birds is through forage and concentrate feeds. In organic production, birds consume every kind of grass within the pasture. This study investigated the performance of slow growing broilers with an outdoor access, documenting the energy balance between slow growers in forage pasture. Four hundred slow growing broilers of Hubbard JA 957 strain were assigned to two Treatments. In Treatment 1, birds were placed in grass/white clover-covered plot and provided with 70 % concentrates adlibitum while in Treatment II, birds were placed in wheat stubble plot and received 35 % concentrate and 35% whole wheat. Each plot had an area of 25m × 10m and enclosed with nets. Results showed that slow growing broilers were not able to compensate their energy requirement resulting to poor weight. Nevertheless, the 70 % concentrates adlibitum diet in wheat stubble plot can be worthy recommendation for farmers since resulting growth rate showed optimistic outcome in terms of farm input due to manure accumulated by soil and an added income for farmers after harvest season.

1. Introduction
In the production of organic broilers, one of the biggest factors in meeting the energy requirements of the birds is to balance the feed from concentrates and foraging. Feeds are formulated so that their metabolizable energy (ME) value reflects the expected needs of the bird at a certain quantitative ad libitum feed intake, predicted from experimental work and from commercial practice in controlled environments [1]. The formulate diets for chickens are based on the recommendations by the National Research Council (NRC) or by specifications from poultry breeders. In organic poultry, the birds consume every kind of grass within the vicinity of the pasture. Grass constitutes a source of energy and fibre, but has a little contribution in terms of protein [1]. Moreover, chickens in the pasture consumed worms, insects, spiders, flies and other invertebrates that increase the intake of protein.

One of the problems in broiler production is high accumulation of excreted nutrients coming from the broilers that will lead to leaching into the soil. Negative impact on the environment like high accumulation of excreta can be avoided through the use of mobile housing. Mobile housing is not so popular in The Netherlands compared to USA, Canada, New Zealand and the United Kingdom [2]. When using a mobile house, stocking rate can be controlled, overgrazing is prevented and damages like digging holes and scratching are minimized and high incidence of parasites around the mobile house can be avoided[3].
Most studies regarding outdoor access are conducted using laying hens, while information on broilers in outdoor areas is still few [4]. Foraging pattern and bird classification are very different from each other, aside from their reproductive management. The protein and energy requirements of broilers in an under sown clover in wheat stubble and in grass-clover pasture were from herbage intake and concentrate feeds [4]. However, protein and energy from insects, worms and other soil fauna were not included in this study.

In the Philippines, raising native/local chicken is grazed in outdoor areas too. Mostly all houses in the rural areas have five to twenty heads native/local chickens for their consumption and additional income. Foraging within the vicinity of the farmers houses to scratch for food is one way of sustaining the native chicken feed requirements. Left overs like rice, desiccated and coconut meat, vegetables are common as feeds to this bird.

Studies on performance of slow growing broilers in pasture of grass clover and wheat stubble with under sown weed are very few. In this paper, growth rate, weight gain and herbage intake of slow growing broilers with an outdoor access was investigated. The energy balance between slow growers in forage pasture was also documented. The use of mobile housing was also considered in the performance of the broilers.

The aim of this study is to identify the gap in the energy balance of free-ranging broilers in wheat stubble and on a grass-clover pasture fed at two different rations and to measure the energy intake from the grazed white-clover sward.

2. Materials and Methods

2.1. Broiler management and treatment design
Four hundred slow growing broilers of the Hubbard JA 957 strain were used in this study. To identify the selected birds, blue and green colours were brushed on the wings of the chicken. The broilers were allowed to graze in the outdoor areas.

2.2. Experimental design
The plots were consisted of grass/white clover and wheat stubble. In each plot, 25 m × 10 m area was enclosed with nets. In grass/grass clover plot, a 70% concentrates of ad libitum were given to broilers as Treatment I while broilers in Treatment II received 35% concentrate and 35% whole wheat. Broilers in Treatment III and IV in wheat stubble plot were fed with 70% concentrates of ad libitum, and 35% concentrates and 35% whole wheat, respectively.

The mobile broiler house (ARM Buildings Ltd. 2006) was divided into four. The house was in the center of the four treatments with two side doors and vent windows that enables fresh air and daylight to access the ark.

2.3. Feed offered
In this experiment, whole wheat was introduced from the start of the diet when the broilers swallow the whole wheat easily. The broiler received four different treatment diets in the morning. In the afternoon, the broilers from all treatment diets received concentrates in the feeding troughs provided inside the house while whole wheat was given to the broilers through broadcast across the outdoor areas where broilers freely move.

| Table 1. Wheat composition offered to the organic broilers. |
|----------------------------------------------------------|
| **Product** | **Dry Matter** |
| Ash | 19 | 22 |
| Crude protein | 124 | 147 |
| Fat | 18 | 21 |
| Crude fibre | 28 | 34 |
2.4. Use of outdoor area
The outdoor area was equally divided into 5 m, 10 m, 15 m, 20 m and 25 m per treatment. The broilers were allowed to graze outside the mobile house.

2.5. Herbage intake
In this experiment, a double sampling method was used in estimating herbage intake of the broiler [5]. Precise estimation of an indirect (height measurements) and direct (cutting technique) measurement were practiced to define the relationship between concomitant variable and the herbage mass by regression.

Dry matter and nitrogen (N) content of the samples were analyzed [5]. For indirect measurement, a simple light disc instrument was used. Also, herbage samples from the nearby area outside the plot were taken. With the mobile house used as the starting point, cutting of herbage samples from all plots were done equally.

Below is the equation used for herbage intake estimation [5]:

\[ C = (Y_s - Y_e) + g \cdot \Delta Y_u \]

Where:

- C = herbage consumed (kg DM·ha\(^{-1}\))
- Y_s = the herbage mass at the start of a grazing period (kg DM·ha\(^{-1}\))
- Y_e = the herbage mass at the end of a grazing period (kg DM·ha\(^{-1}\))
- g = growth rate (kg DM·ha\(^{-1}\)·day\(^{-1}\))
- \Delta Y_u = the change in herbage mass (kg DM·ha\(^{-1}\))

Below is the table for nutrient composition offered to the organic broilers:

| Nutrient Composition       | %   |
|----------------------------|-----|
| Crude protein              | 21  |
| Crude fat                  | 5   |
| Crude fibre                | 5   |
| Raw ash                    | 6   |
| Starch                     | 40  |
| Sugar                      | 3   |
| Remaining carbohydrates    | 8   |
| Water                      | 12  |

Note: Water was given to the broilers every morning throughout the experiment.

Figure 1. Layout of the four experimental plots with different treatment diets.
Ye= the herbage mass at the end of a grazing period (kg DM·ha⁻¹)
ΔYu= undisturbed herbage accumulation in exclosure during a grazing period (kg DM·ha⁻¹)

2.6. Energy requirement and balance
Maintenance and growth were calculated to determine the energy requirements of broilers. This equation does not correct for a high activity level but for varying temperatures to which the broilers were exposed to.

Maintenance: \(435*W^{0.75} + 9, 5*\Delta T + 21, 5*G\) = Total energy requirements

Where:
W= body weight (in kg),
\(\Delta T\)= deviation in ambient temperature with regard to 25 °C,
G= growth (in g·day⁻¹)

2.7. Statistical analysis
For this study, ANOVA – Two way factor was used to analyzed the interaction between the plot, feed given and weight gain.

3. Results and Discussion

3.1. Mortality rate
The mortality rate was 3.14% which is higher than the mortality of the previous experiment done on Droevendaal farm which was 1.84% [6]. During the experimental period, the weather changed from sunny to windy and then from cold to rainy which can be attributed to the unknown cause of death of broilers.

3.2. Herbage intake and feed offered
For estimated herbage intake, the different herbage heights (concomitant variables) were measured in the experimental area. To calculate the herbage intake (C) [5], Ys, Ye and ΔYu had to be known (table 3). For 14 days the broilers were given 10.0 kg concentrates and 7.0 kg whole wheat grain kernels per treatment/day. The herbage intake was 14 gram/broiler/day and 10 gram-broiler/day for the grass/white clover and 35% concentrates, 35% wheat group, respectively. The average intake of herbage for both groups was 12 g DM per broiler.

| Plot 1 70 % concentrates of ad libitum | Plot 2 35 % concentrates, 35 % whole wheat |
|--------------------------------------|------------------------------------------|
| Ys (kg DM·ha⁻¹)                      | 2778                                     | 2280                                     |
| Ye (kg DM·ha⁻¹)                      | 2021                                     | 1763                                     |
| C                                    | 757                                      | 517                                      |
| Intake of herbage (g DM/broiler/day) | 14                                       | 10                                       |
| Intake of offered wheat (g/broiler/day) | 71                                      | 71                                       |
| Intake of concentrates (g/broiler/day) | 101                                     | 101                                      |
| Feed Conversion Ratio (FCR)          | 5.5                                      | 7.4                                      |
| FCR= kg offered feed/kg live weight gain |                                          |                                          |
3.3. Gain in weight
The first weighing was done at 35 days age of the broilers. Mean live weight was 461 g per broiler for the 70% of ad libitum group and 477 g per broiler for the 35% concentrates, 35% wheat group. At day 98, mean live weight of all broilers from the 70% of ad libitum group was 2870 g per broiler and from the 35% concentrates, 35% wheat group was 2423 g per broiler. Mean total weight gain from 35 to 98 days was 2409 g per broiler fed with 70% of ad libitum diet and 1947 g per broiler for 35% concentrates 35% wheat diet. Calculated mean total weight gains are lower than mean final body weight of all broilers (2178 g vs. 2646g).

Daily weight gain for the entire outdoor period (35–98 days) was 38 g per broiler fed with 70% of ad libitum and 31 g per broiler for those fed with 35% concentrates, 35% wheat.

![Figure 2. Mean growth in kg of 20% of the broilers from each treatment diet in relation to age in days (35–98 days).](image-url)

3.4. Energy requirements
Energy requirements were calculated at 14 days of grazing outside the mobile house (CVB 2000). To calculate for the deviation in ambient temperature, the mean day temperature outside the mobile house and the minimum night temperature inside the house were taken into account. Maintenance and growth were determined using average body weight and growth within the specified grazing period (14 days). In the energy intake source, others refers to all feed consumed in the outdoor areas except for herbage. Examples are worms, insects, bugs and other soil animals. In the grass, grass clover plot fed with 70% ad libitum, the needed energy derived from offered feed was 82% while 18% from herbage and other feed components taken by the broilers in the outdoor areas. In the 35% concentrates, 35% whole wheat diet, 80% needed energy from offered feed and 20% came from herbage and other feed found in the outdoor areas. For the wheat stubble plot, the broilers fed with 70% ad libitum had 75% needed energy from offered feed and 25% coming from other feed components found in the grazing areas. Broilers fed with 35% concentrates, 35% whole wheat had 80% needed energy derived from offered feed and 20% came from other feed source in the outdoor areas.

4. Conclusion
In this study, feeding slow growing broiler with a restricted diet such as 70% ad libitum in an outdoor area and in so late in the year is not highly recommendable. Slow growing broilers cannot compensate their energy requirement which resulted to poor weight gain. On the other hand, the 70% ad libitum diet in wheat stubble plot can be a worthy recommendation for organic broiler farmers.

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