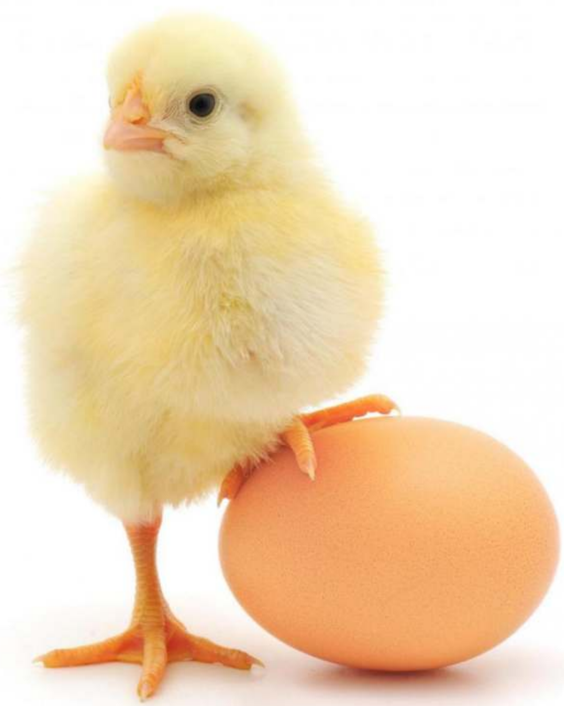
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 3 (11): 728-732, 2004

Metabolizable Energy of Crop Contents in Free-range Hens

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Abstract: The composition and apparent metabolizable energy (AME) of the feed resources consumed by free-range layers was assessed by analyzing their crop contents. A chemical estimate of the AME of crop contents was 14.3 MJ/kg for hens not supplemented and 15.5 MJ/kg for hens given supplementary compound feed (on a dry matter basis). These values were considerably higher than the AME values estimated on crop contents based on ingredients visually identified in the crop (6.6 MJ/Kg with no supplement and 10.4 MJ/Kg with supplement). Further studies are required to refine the measurement of AME based on crop contents. Behaviour of free-range birds provided supplementary feed was compared to layers retained in an enclosure with no additional feed. Birds with access to the range had more ($P<0.05$) seeds and insects in their crops and exhibited greater ($P<0.05$) incidences of running, walking and wing flapping reflecting greater freedom of movement. In the enclosure, birds engaged in more ($P<0.05$) scratching and foraging.

Key words: AME, crop contents, behaviour

Introduction

One of the difficulties nutritionists have in developing rations for free-range birds is to determine the nutritional value of forage and quantity of forage consumed. Once these values are known the level and quantity of supplementary feed can be determined.

Wood *et al*. (1963) indicated that studies on the crop contents of free-range birds can help determine the food habits and preferences of chickens, and provide an indication of the amount of supplementary feed required. Variable amounts of vegetation, earthworms and insects are available for hens (Tadelle and Ogle, 2003). While chickens are foraging they consume insects, green leaves, stones, seeds, farm wastes and food scraps. The activities that birds engage in during foraging such as scratching, browsing and searching is related to their energy requirements (Wood-Gush, 1971).

The AME value is an important measure of the relative usefulness of a feed. Carpenter and Clegg (1956) developed a chemical method for estimating AME of poultry feed. Many other prediction equations have been developed; eg. (Waldroup, 2003; Sibbald *et al*., 1980).

The AME of individual feed components such as carpet grass, oats and meat and bone meal have been determined (Leche *et al*., 1982; Farrell, 1983). On the basis of these values it may be possible to predict the AME content of feed based on the visual identification of the feed components in the crop of the bird.

This study focused on predicting the AME of the crop contents of free-range laying hens by a chemical method and also by the feed components identified in the crop. A comparison was made of the AME from crop contents and behaviour of birds with access to forage only (to simulate the conditions in some free-range systems) versus birds, which were fed a commercial feed with access to pasture.

Materials and Methods

Paddocks: The experimental work was located in East 2 paddock at Roseworthy Campus, University of Adelaide. This project was a small study within a larger trial (Glatz and Ru, 2004) where a 4-ha paddock was divided into 8 smaller fenced paddocks. Four plots were grazed by poultry. There were 55 hens per plot with a stocking density of 110 hens/ha.

Shelter: An eco shelter was constructed in the centre of the paddock. It was made up of light steel framework covered by a high ultra violet protective shade cloth. Curtains were fitted on the 4 sides of the shelter to enable manual manipulation of the ventilation. Birds were provided nest boxes, perches, feeders and drinkers in the shelter but no artificial light.

Enclosures: In each of the poultry paddocks a small exclusion pen was constructed. The pen was built with 4 metal stakes and wire mesh 1m high. Hessian was used to cover the wire mesh to prevent the birds inside the pen having visual contact with other birds. A surveillance camera was mounted on the exclusion pen to record behaviour.

Birds: Four birds (Hyline Brown layers, 45 weeks old) were selected at random from each paddock. Two birds were placed in the exclusion pen with no supplementary feed while the other two birds were part of the larger

Table 1: The ingredients and proximate nutrient analysis of the commercial feed provided as a supplement for free range hens

Ingredients	Kg	%	Analysis	
Barley	300	29.86	Dry Matter	90%
Canola Oil	10	1.00	Protein	16.6%
Choline Chloride	0.95	0.09	Fat	3.48%
Hard Grit	20	1.99	Fibre	3.54%
Limestone	52.5	5.23		
Lysine	0.4	0.04		
Meat Meal	75	7.47		
Methionine	1.8	0.18		
Peas	140	13.94		
Poultry Vitamins	1	0.10		
Ravabio	0.5	0.05		
Salt	1.6	0.16		
Sodium Bicarb	0.85	0.08		
Soybean Meal	20	1.99		
Wheat	380	37.83		
TOTAL	1004.6	100.00		

flock and were allocated 110g/b/day of a standard layer ration (Table 1). There were two treatments (supplemented and not supplemented) and four replicates (2 birds/replicate).

Behaviour Observations: In this study video surveillance was used to monitor the behaviour of the birds in the exclusion pens. Birds were monitored over an 8h period. Each bird was observed three times over 10 min intervals. The video record was monitored using the instantaneous sampling procedure (Lehner, 1996). Variables monitored were; sit, stand, sleep, drink, eat, forage, scratch, feather ruffle, dust bathe, preen, peck other birds, peck fence, peck post, lay, leg stretch, wing stretch, walk, run, pace and flap. The birds in the range were observed with binoculars from outside the paddocks to avoid disturbing their behaviour.

Collection of Crop Contents: After an 8h grazing period birds were euthanased with 0.5 ml of lethabarb, the crop was dissected and crop samples collected. Wet and dry weight of crop samples (to nearest 0.01g) were obtained and then stored in plastic cups, sealed in plastic bags, and stored at -4°C to prevent digestion of the crop contents.

Classification of crop contents: The low magnification (10x) of an Olympus microscope was used to classify the crop contents. A pair of forceps was used to tease apart the contents to identify the larger materials such as leaves, stones, seeds, insects, sticks and other obvious materials. At a higher magnification (20x) the same procedure was carried out for the smaller components. The materials left were categorised as unidentified materials.

Chemical analyses: Crude protein, carbohydrates, fat and starch were measured according to the methods described by AOAC (1980). On the basis of contents in the crop the ME was predicted using AME values of similar forage material (Leche *et al*., 1982; Farrell, 1983).

Statistical analysis: Base SAS Software (Statistical Analysis Systems Inc, 1988) was used to perform an analysis of variance (by GLM procedure) to determine treatment differences between crop contents and the behaviour of birds. Duncan's multiple range test was used to separate the treatment means.

Results

Crop contents: The dry weight and fresh weight percentage of each category identified in the crop is shown in Table 2. The dry and wet weight and percentage of seeds and insects found in the crop were significantly higher ($P < 0.05$) for birds in the range. However the dry weight of plant material in birds not supplemented was significantly higher than birds on the range.

Chemical estimate of AME: The equation below proposed by Sibbald *et al*. (1980) was used to estimate the AME using crude protein (CP), either extract (EE), crude fibre (CF) and starch (STA) analyses of the crop contents (Table 3).

AME (Cal/Kg) = (0.59 x %DM) + 38B (adjusted to MJ/KG)

Where;

B = (CP% + 2.25 x EE + 1.1 x STA% + CHO%)

DM = Dry Matter (approximately 90%) as air-dry basis.

The AME of crop contents resulting from this calculation was 14.3 MJ/Kg for birds in the exclusion pen and 15.5 MJ/Kg for supplementary fed birds on a dry matter basis.

AME estimate based on crop components: Table 4 shows the alternative approach used to predict the AME of crop contents. It was assumed that the AME values for oats, meat and bone meal and carpet grass were a reasonable approximation for the AME value of seeds, insects and plant material identified visually in the crop. This calculation of the AME did not include an estimate of AME of unidentified materials.

The equation used was;

AME (MJ/kg) = (11 x % insects + 7.2 x % plant materials + 13.5 x % seeds)

The AME values were 6.6 MJ/Kg with no supplement and 10.4 MJ/Kg with supplement.

Behaviour: The birds not provided supplementary feed foraged and scratched more ($P<0.05$) than hens provided supplementary feed (Table 5). Birds not restricted to the exclusion pen walked and ran more ($P<0.05$) but had greater incidences ($P<0.05$) of sleeping and flapping their wings than birds retained within the enclosure (Table 5).

Table 2: Comparison of the fresh and dry weight (g and %) of crop contents for hens in an exclusion pen with 8h access to forage versus hens with access to compound feed, other forage sources and the free-range

Variable	Exclusion Pen	Free Range	P	LSD (P=0.05)
Fresh wt (g)				
Seed	1.51a	12.85b	0.013	8.54
Plant	3.00	4.34	0.39	NS
Insect	0.28a	1.56b	0.007	0.88
Stone	0.80	1.23	0.57	NS
Other	0.24	0.42	0.40	NS
Fresh wt (%)				
Seed	25.9a	62.99b	0.0001	13.97
Plant	51.46a	21.27b	0.0012	17.9
Insect	4.80	7.65	0.14	NS
Stone	13.72	6.03	0.37	NS
Other	4.12	2.05	0.19	NS
Dry wt (g)				
Seed	0.63a	5.22b	0.008	3.18
Plant	1.18	1.69	0.42	NS
Insect	0.09a	0.79b	0.005	0.46
Stone	0.49	0.88	0.43	NS
Other	0.18	0.26	0.60	NS
Dry wt (%)				
Seed	24.51a	59.04b	0.0001	12.25
Plant	45.91a	19.12b	0.0042	18.23
Insect	3.50	8.94	0.12	NS
Stone	19.07	9.95	0.09	NS
Other	7.0	2.94	0.27	NS

Means in rows with a different letter are significantly different (P<0.05). LSD=least significant difference. NS=not significant in analysis of variance. P=probability in analysis of variance

Table 3: Nutrient analysis of the crop contents of birds in the exclusion pen and in the free-range

	Exclusion Pen %	Free Range %
Crude Fat	3.16	3.25
Crude Protein	14.28	13.5
Crude Fibre	5.6	5.44
Total Starch	30.4	32.25
Available Carbohydrate	33.79	39.93

Table 4: AME of poultry feedstuffs used for predicting AME of crop contents

	MJ/kg	References
Oats	13.5	Farrel, 1983
Meat and bone meal	11.0	Farrel, 1983
Carpet grass	7.2	Leche *et al.*, 1982

Discussion

Birds given supplementary feed consumed a significantly higher fresh weight of insects and seeds. The birds in the range had more area to forage and consumed more insects than birds limited to the enclosure. A greater quantity of seeds was found in the crop contents of birds in the range. However the percentage of plant material consumed by birds relative to total weight of forage consumed in the crop was significantly higher in birds not provided supplementary feed. There were a higher (p=0.09) percentage of stones in the crop contents in birds inside the enclosure, presumably to aid the breakdown of fibrous components of the diet consumed.

There was a difference in the composition of the crop contents of our study compared to the Tadelle and Ogle (2003) study in a tropical environment (Table 6). Two factors caused the difference. Firstly our study was in a Mediterranean environment and forage sources are markedly different from the tropical environment. Secondly data collected by Tadelle and Ogle (2003) was over different seasons of the year whereas our study was undertaken in summer.

The equation used in our study to predict AME was designed for a compound feed rather than for a single ingredient or for assessing forage. In free-range environments Thear (1997) has recommended 11.5 MJ/Kg for laying hens. The chemical estimate of AME of the crop contents was 14.31 MJ/kg for birds not supplemented and 15.52 MJ/kg for birds supplemented. The results suggest that the diet consumed by birds was sufficient in energy, (assuming that the prediction is accurate). The higher energy of crop contents from the birds in the range is clearly due to their access to compound feed. In addition more insects were available

Table 5: Incidence of behaviours of hens in an exclusion pen (with access to forage only) compared to hens with access to compound feed, other forage sources and the free-range. Data was recorded over 3 ten min observation periods from 0900 - 1700h

Variable	Exclusion Pen	Free Range	P	LSD (P=0.05)
Sit	0.5	0	0.48	NS
Stand	1.0	0.375	0.07	NS
Sleep	0a	0.875b	0.04	0.85
Drink	0.375	0.25	0.69	NS
Eat	0a	0.875b	0.02	0.75
Forage	2.5a	1.125b	0.02	1.175
Scratch	3.125a	0.875b	0.0001	0.796
Feather ruffle	0	0	-	-
Dust bathe	0	0	-	-
Preen	0.25	0.125	0.55	NS
Peck other birds	0	0.125	0.33	NS
Peck fence	0	0.125	0.33	NS
Peck post	0	0.125	0.33	NS
Lay	0.125	0	0.33	NS
Leg stretch	0	0.125	0.33	NS
Wing stretch	0.125	0	0.33	NS
Walk	2.0a	3.125b	0.01	0.85
Run	0a	0.125	0.0025	0.803
Pace	0a	1.125b	0.33	NS
Flap	0	1.125	0.03	1.027

Means in rows with a different letter are significantly different (P<0.05). LSD=least significant difference. NS=not significant in analysis of variance. P=probability in analysis of variance.

Table 6: Dry weight of crop contents from Tadelle and Ogle (2003) compared to birds in exclusion pen and free range in the current study

	Crop Contents %		
	Tadelle and Ogle (2003)	Exclusion Pen	Free Range
Seeds	30.9	17.8	55.3
Plant materials	23.3	51.2	22.1
Worms	6.7	-	-
Stones	-	20.8	7.9
Insects	11.1	4.5	11.4
Unidentified materials	23.9	5.8	3.4

to consume compared to birds limited to the exclusion pens. The crop contents assessment gives an indication of the diet of birds. The chemical analysis indicates that crop contents have a high energy value. However this does not mean hens will utilize all this energy. The contents of the crop were mainly fibrous materials and not as readily digestible as compound feeds.

The AME predicted by assessing the dietary components in the crop was lower than the chemical method. The crop content energy was 6.64 MJ/kg for birds limited to the exclusion pen and 10.4 MJ/kg for birds in the range. This result suggests that the energy content of feedstuffs used in the prediction were not a good match for the crop components found in our study. In addition the energy of unidentified materials was not taken into account when using this prediction. It is likely compound feed residues were still left in the crop of the birds from the previous day. These could form part of the unidentified materials. Clearly the unidentified material has contributed to energy of the crop contents in the chemical method while they have been ignored in the method based on components identified in the crop. The chemical estimate of AME of the crop would be closer to the actual AME value of feed. Birds will select diets or diet components to meet their nutritional needs. The birds not provided supplementary feed were able to do this but volume of feed available in the exclusion pen was the limiting issue. Behaviour of birds in the range indicated their energy intake was sufficient. The birds in the range exhibited a greater incidence of walking, running and flapping wings than birds in the enclosure reflecting greater freedom of movement to search for insects and forage.

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