

New Model for Examining the Energy Metabolism of Laying Hens

A.S. Leaflet R2805

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Summary and Implications

An experiment was conducted to evaluate the energy utilization of laying hens fed diets containing two energy concentrations, using a holistic approach including measurement of productive, maintenance and storage energy. The experiment was a 2 x 2 factorial arrangement with two feeding levels (*ad libitum* and restricted feeding of 90 g feed/hen-d), and two dietary energy levels (HE-high metabolizable energy or ME content of 2,880 kcal/kg; and LE-low ME content of 2,790 kcal/kg). A total of 60 Hy-Line W36 first-cycle laying hens were fed treatment diets for 12 wk from hen age 27 to 39 wk, with 15 individually housed hens for each of the four treatments. There were no interactions between feeding levels and dietary energy levels throughout the experiment. Feed restriction resulted in significant reductions ($P \leq 0.01$) in egg production, body weight, and abdominal fat pad weight, indicating reduced nutrient availability to partition the energy towards production, maintenance, and storage functions, respectively. Reduced energy intake did not change the energy partitioned and utilized towards production (egg production) or maintenance (body weight), but significantly reduced ($P = 0.03$) the energy stored (reduced fat pad). These results suggest that energy utilization follows the pattern of production and maintenance before storage requirements in Hy-Line W36 laying hens.

Introduction

Energy is an expensive component in poultry rations as consumption of energy increases rapidly around the world. Energy costs will continue to drive grain prices, as more grain is diverted towards bio-fuel production. Understanding energy intake and partitioning patterns of the modern laying hen has become increasingly important to improve the dietary energy utilization efficiency and to control feed costs. Historic research has demonstrated that laying hens change feed intake patterns to meet energy requirement, thus feed intake and subsequent hen productivity can change. Recent published results have contradicted historic data for at least small framed laying hens. Therefore it is important to reevaluate energy utilization in these modern laying hens. In an attempt to develop a holistic model to validate energy metabolism in laying hens, a short-term experiment was proposed with the hypothesis that changes in dietary energy will be reflected by a modification in the

combination of maintenance, productive and storage energy metabolism. The objective was to characterize the energy utilization pattern of laying hens when fed a corn - soybean meal - dried distillers with solubles based diet with two energy concentrations under either *ad libitum* or restricted feeding regimen over a 12 wk experimental period.

Materials and Methods

Experimental Design

A total of 60 Hy-Line W36 hens were fed four experimental diets from 27 to 39 wk of age, with two feeding levels (*ad libitum* and restricted feeding of 90 g feed/hen-d) and two dietary energy concentrations (HE - high metabolizable energy or ME content of 2,880 kcal/kg, and LE - low ME content of 2,790 kcal/kg) in a 2 x 2 factorial arrangement. Each experimental unit (EU) was defined as an individually-housed hen (192 in²) to better quantify bird feed intake and reduce aggressiveness among hens over competition for feed. Each of the four treatment groups comprised of 15 EU to account for possible mortality or poor egg producers to maintain suitable replication. Hen day egg production (HDEP) was determined daily, feed intake was determined weekly, while body weight (BW) was measured every 4 wk. Egg weight (EW) was measured bi-weekly and egg mass produced was calculated as follows:

$$\text{Mean egg mass (g)} = [\text{Mean EW (g) for 5 d} \times \text{No. of eggs produced over the wk}] / 7$$

Abdominal fat pad weight (FPW) of all the hens was measured at the end of wk 12 after euthanization. Excreta samples were collected for the last 5 d of wk 12 and gross energy (GE), nitrogen (N) and titanium dioxide (Ti) levels were determined for diet as well as excreta samples to calculate nitrogen corrected apparent metabolizable energy (AMEn) as follows:

$$\text{AMEn (kcal/kg)} = \text{Diet GE} - [\text{Excreta GE} \times \text{Diet Ti} / \text{Excreta Ti} - 8.22 \times (\text{Diet N} - \text{Excreta N} \times \text{Diet Ti} / \text{Excreta Ti})]$$

The data were analyzed by MIXED procedure of SAS with protected least square means (LSM) to separate means and student's t-test ($\alpha = 0.05$; $t = 1.98698$) to separate significant LSM with the probability of type-I error set at $P \leq 0.05$.

Results and Discussion

There was no mortality and no hens were removed or culled during the experimental period. No interactions were found between dietary energy concentrations and feeding regimens in feed intake, HDEP, EW, egg mass, BW, AFP or AMEn. Feed restriction led to 10% reduction in feed intake ($P \leq 0.01$) and 4% reduction in HDEP ($P \leq 0.01$) relative to the *ad libitum* fed group. There were no significant

differences in EW, egg mass, or feed:egg mass conversion ratio between the feeding regimens. Body weight of hens in the restriction-fed group started to decline gradually ($P \leq 0.01$) by 10% in the first eight wk and eventually by 14% ($p \leq 0.01$) at the end of wk 12 compared to the *ad libitum* fed group. Reduced HDEP and body weight of feed restricted hens indicate their energy prioritization pattern starting with production followed by maintenance. However, hens fed differing dietary energy concentrations did not differ significantly in feed intake, HDEP, EW, egg mass, feed:egg mass conversion ratio, or BW. These observations that dietary energy levels failed to change the productive or maintenance responses indicate that feed intake of Hy-Line W36 laying hens is not driven by dietary energy content.

There were no significant differences in AMEn between the feeding regimens or different dietary energy levels. The spread of individual AMEn, when compared between the dietary energy concentrations as well as feeding regimens, was approximately 500 kcal/kg. These data indicate that the large individual variability associated with laying hen digestibility may preclude generation of

significant differences when diets of various energy concentrations are fed. The FPW of feed-restricted hens was reduced by 51% ($P \leq 0.01$) compared to *ad libitum*-fed birds while the LE- fed birds had 23% reduced FPW compared to HE-fed birds. The reduced FPW of the feed-restricted group as well as LE-fed hens may be due to the insufficient dietary energy availability, suggesting that limiting energy supply changes body composition, primarily at the cost of fat deposition in Hy-Line W36 laying hens. These data suggest that, over a short-term experimental period, FPW may be a more sensitive dietary energy marker or response criterion, than HDEP or BW.

In conclusion, feed intake of hens did not change with dietary energy concentrations, indicating that feed intake has little or no sensitivity to dietary energy content in Hy-Line W36 laying hens. Dietary energy concentration and or feed restriction significantly reduced FPW but failed to influence AMEn. This outcome also underscores the importance of a comprehensive approach to laying hen energy metabolism rather than reliance on one performance variable.

Table 1. Effect of dietary energy, with or without feed restriction in Hy-Line W36 laying hens fed corn-soybean meal-dried distillers with solubles based diets from 27 to 39 wk of age.

Dietary Groups	Feeding Groups	FI (g/hen/d)	HDEP (%)	Feed/EM (g/g)	BW (kg)	AMEn (kcal/kg)	FPW (g/hen)
High ME		91.2	93.8	1.72	1.41	3391	39.0 ^a
Low ME		92.5	94.5	1.73	1.39	3337	30.2 ^b
	<i>Ad libitum</i>	96.8 ^a	95.9 ^a	1.75	1.44 ^a	3368	46.5 ^a
	Restricted	86.8 ^b	92.3 ^b	1.70	1.35 ^b	3359	22.7 ^b
Pooled SEM		1.04	0.83	0.02	0.02	28.50	2.74
Overall <i>P</i> -value		≤ 0.01	0.02	0.08	≤ 0.01	0.48	≤ 0.01
Dietary Groups <i>P</i> -value		0.40	0.55	-	0.17	-	0.03
Feeding Groups <i>P</i> -value		≤ 0.01	≤ 0.01	-	≤ 0.01	-	≤ 0.01
Diet x Feeding <i>P</i> -value		0.58	0.71	-	0.91	-	0.57

Values are reported as least square means (LSM).

LSM in the same column not sharing a common superscript differ significantly, $P \leq 0.05$.

FI=Feed intake; HDEP=Hen day egg production; Feed/EM=Feed intake/Egg mass conversion ratio; BW=Body weight; AMEn=Nitrogen corrected apparent metabolizable energy; and FPW=Abdominal fat pad weight

Acknowledgements

We would like to acknowledge Evonik Degussa Corporation for providing Bio-lys and DL-Methionine, Feed Energy Company for fat, Lincoln Way Energy LLC for DDGS, and ILC Resources for limestone. We recognize the care for the birds provided by W. Larson, J. Tjelta, W. Rogers, and R. Holbrooke of Iowa State University poultry research center, and also like to thank N. Nachtrieb, K. Nesheim, M. Higgins and J. Green for assistance in conducting this experiment.