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Effects of Cage Density and Level of Added Fat on Laying Hen Performance[1]

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ABSTRACT

Four hundred and thirty two (432) pullets, 24 weeks old, were divided into 9 groups in a 3×3 factorial arrangement according to level of added fat (0, 3 and 6%) or cage density (310, 413 and 619 cm^2/bird). There were 4 replicates in each treatment. The experiment lasted for nine, 28-day periods (252 days). There were significant effects of cage density and level of added fat on hen-day feed consumption, feed efficiency, and hen-day production. There were also significant effects of cage density on hen-housed production and on egg weight. None of the variables showed significant interaction between cage density and level of added fat. Hens provided with 310 cm^2 cage floor space per bird produced less egg, consumed more feed and utilized feed less efficiently than hens with 413 or 619 cm^2 of cage floor space per bird. Hens provided with 619 or 413 cm^2 of cage per bird performed equally well.

As the level of added fat was increased, feed consumption was decreased and feed efficiency was improved. However, feed efficiencies of rations with 3 or 6% added fat were not significantly different. Mortality among hens with 310 cm^2 of cage floor space per bird was about 16% compared with less than 4% mortality among the other two groups.

INTRODUCTION

The usefulness of fat supplementation in laying hen rations has been the subject of several studies since the early 1950's. The main objective of these studies was to make use of the large quantity of animal fat produced as a by-product of the meat packing industry. Several of these studies were reviewed recently by Horani and Sell (5). Fats are known to provide more than just energy to poultry rations; they reduce dustiness and wastage of feed, improve appearance and palatability of feed, and they act as a lubricant in the feed mixing machinery.

The performance of laying hens under various cage densities has been investigated by several researchers. Wilson *et al.* (12) reported that egg production was significantly ($P < 0.01$) reduced when caged layers had 310 cm^2 of floor space per bird,

[1] *This experiment was conducted at the Poultry Research Center of North Dakota State University, Fargo, N. Dakota in 1976.*

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compared to 465 or 930 cm^2/bird. However, no effect on feed consumption was noticed. Owings *et al.* (8) found that caged hens with floor space of 345 cm^2/bird had lower egg production compared to hens with 516 cm^2/bird even though feed efficiency was similar. According to Adams and Jackson (1), birds housed in cages with floor space of 350 cm^2/bird laid significantly less eggs than birds with 700 cm^2 of floor space/bird. Similarly, the effects of cage size were found to be significant within each floor space category. However, Marr and Greene (7) found no significant difference in egg production and in egg weight among social densities of 2, 3, 4, 5, 6 or 7 hens with comparable space/bird. Ruszler and Quisenberry (9) concluded that density increases had greater depressing effects on egg production than population increases. They also found that when cage density increased, thus providing 290 cm^2/bird instead of 348 or 406 cm^2/birds, egg size and the percentage of large eggs produced tended to increase. Increasing cage density resulted in lower egg production and higher mortality, but no effect on egg weight, feed consumption and feed efficiency (4).

Recently, Foss and Carew (3) investigated the effects of energy level and cage density on laying hen performace. The dietary treatments consisted of three levels of metabolizable energy (2737, 3003, and 3322 Kcal/kg of ration), and cage densities were 697, 465 and 348 cm^2/bird. Hen performance was improved as the floor space/bird was increased. Mortality was increased as the dietary energy level increased and as the floor space/bird decreased. Thus the researchers concluded that the heigh bird densities, extra dietary energy might be detrimental to both egg production and liveability. Sefton(10) concluded that area/bird is more important than number of birds/cage. He also confirmed that when area/bird was reduced and number of hens/cage was increased, egg production was significantly reduced.

It was the objective of this work to investigate the effects of three cage densities (619, 413 and 310 cm^2/bird) on the performance of laying hens when fed rations with 0, 3 and 6% added feed grade animal fat.

MATERIALS AND METHODS

Single Comb White Leghorn pullets of commercial strain were used in this experiment which lasted for 252 days. The pullets were 24 weeks old and their level of egg production was about 50% when the experiment started. Stair-type cages (30.5 cm × 40.6 cm) were used. Four hundred and thirty two (432) pullets were randomly divided into 3 groups of 144 pullets each, and were placed 2, 3 or 4 pullets per cage. Thus 3 cage densities of 619, 413 and 310 cm^2/bird were created. Each group, of 144 pullets, within each cage density was subdivided into 3 subgroups of 48 pullets each that were fed rations with 0, 3 or 6% added feed grade animal fat. The design of the experiment was a 3×3 factorial, and there were 4 replicates, of 12 pullets each, in each treatment. Feed and water were provided ad lib. and light was kept at 14 hours/day. Egg production and mortality were daily recorded, and feed consumption records were kept for each 28-day period. On the last three days of the third, sixth and ninth periods all eggs collected from each replicate were counted and weighed. The ingredient composition of the three rations fed is presented in Table 1. The metabolizable energy (ME) values of rations with 0, 3 and 6% added fat were calculated to be 2823, 2924 and 3019 Kcal/kg ration. All rations had a constant calorie to protein ratio (176 Kcal of ME per kg for each percentage of protein).

Data were analysed statistically by analysis of variance (11) and by Duncan's multiple range test whenever applicable.

Table 1 The ingredient composition of the three rations fed to laying hens.

Ingredient	No added fat	3% added fat	6% added fat
		(% of ration)	
Corn	69.4	64.0	58.7
Soybean meal (44%)	20.0	22.4	24.7
Meat and bone meal	2.0	2.0	2.0
Ground limestone	6.0	6.0	6.0
Dicalcium phosphate	2.0	2.0	2.0
Salt premix[1]	0.3	0.3	0.3
Vitamin premix[2]	0.25	0.25	0.25
DL-methionine	0.05	0.05	0.05
Feed grade animal fat	—	3.0	6.0

[1] The salt premix supplied 30 ppm of Mn and 2.9 g of NaCl per kg of ration.
[2] The vitamin premix supplied the following per kg of ration = vitamin A, 11,000 IU; vitamin D_3, 4,400 I.C.U.; vitamin E, 8.8 I.U.; vitamin B_{12}, 0.0133 ug.; riboflavin, 6.6 mg; niacin, 33 mg.; menadione sodium, bisulfite complex, 2.2 ug; folio acid, 0.44 mg; choline, 660 mg; D-pantothenic acid, 6.6 mg; ethoxyquin, 125 mg.

RESULTS AND DISCUSSION

There were significant effects of cage density on hen-day feed consumption ($P<0.05$), feed efficiency ($P<0.01$), hen-day production ($P<0.05$), hen-housed production ($P<0.01$) and egg weight ($P<0.05$). The level of added fat had significant effects on hen-day feed consumption ($P<0.01$), feed efficiency ($P<0.01$) and hen-day production ($P<0.05$). None of the variables showed significant ($P<0.25$) interaction between cage density and level of added fat.

The effect of cage density and level of added fat on hen-day feed consumption is shown in Table 2. The addition of fat to the ration resulted in a significant ($P<0.05$) reduction in feed consumption. This reduction was expected since rations with added fat had higher ME contents, and since chickens eat mainly to satisfy their energy requirement. The average hen-day feed consumption of hens fed the 0, 3 and 6% added fat rations were 110.6, 104.7 and 99.3 grams, respectively. In terms of ME intake, this would amount to 312, 306 and 300 Kcal/hen-day. Thus it appeared that the addition of fat caused a reduction in hens' energy intake. This is not highly probable, and one should question the validity of the calculated ME values of these rations. Horani and

Table 2 Effect of cage density and level of added fat on hen-day feed consumption (in grams).

	Cage density			
Level of added fat	4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	111.4 ± 1.9^{1a}	111.4 ± 2.7^{2a}	109.0 ± 1.3^{ab}	110.6 ± 1.9^{X}
3%	108.7 ± 2.5^{ab}	103.5 ± 1.8^{bc}	102.0 ± 0.4^{cd}	104.7 ± 2.2^{Y}
6%	102.4 ± 2.3^{cd}	98.6 ± 1.0^{cd}	97.0 ± 1.5^{d}	99.3 ± 1.9^{Z}
Average	107.5 ± 2.8^{A}	104.5 ± 3.3^{AB}	102.7 ± 2.8^{B}	

[1] Means of 4 replicates ± SE.
[2] Means without a common letter are significantly different ($P<0.05$).

Sell (6) have previously calculated and measured the ME content of these rations. Their measured ME values, converted here to be on as fed basis, were 2722, 2849, and 3010 Kcal/kg of the rations with 0, 3 and 6% added fat, respectively. Consequently, energy intake, based on measured ME values, would be 301, 298 and 299 Kcal/hen-day, respectively. Thus energy intake based on these values was equalized regardless of the addition of fat to the rations. Horani and Sell (5) referred to this phenomenum as an 'extra metabolic effect' of fat, by which added fat would contribute more than its known ME value to the ration. Results shown in Table 2 clearly demonstrate that feed consumption of hens housed 4 birds/cage was significantly ($P < 0.05$) higher than that of hens housed 2 birds/cage. These results were contrary to the findings reported by Wilson *et al.* (12) and Grover *et al.* (4). In terms of energy intake, based on calculated or measured ME values, the results of this experiment indicate that there was an increase in this parameter when hens were housed 4 birds/cage rather than 2 birds/cage. Apparently, energy requirement would increase if hens were subjected to a stress of crowding.

Table 3 shows the effects of the various treatments on feed efficiency. Feed efficiency of hens provided with 413 or 619 cm^2/bird was significantly better than that of hens with 310 cm^2/bird. This was a reflection of the increased feed consumption and the decreased egg production of the hens housed 4 birds/cage. It is of a practical interest to note that hens provided with 413 cm^2/bird performed as well as hens with 619 cm^2/bird. In fact, egg production was slightly higher and feed efficiency was almost the same.

Table 3 Effect of cage density and level of added fat on feed efficiency (kg feed/dozen eggs).

	Cage density			
Level of added fat	4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	1.66 ± 0.05^{1a}	1.59 ± 0.03^{2a}	1.56 ± 0.01^{ab}	1.60 ± 0.04^{X}
3%	1.62 ± 0.06^{a}	1.48 ± 0.03^{b}	1.50 ± 0.03^{b}	1.53 ± 0.05^{Y}
6%	1.60 ± 0.03^{ab}	1.46 ± 0.03^{b}	1.45 ± 0.03^{b}	1.50 ± 0.04^{Y}
Average	1.63 ± 0.05^{A}	1.51 ± 0.04^{B}	1.50 ± 0.03^{B}	

[1] Means of 4 replicates ±SE.
[2] Means without a common letter are significantly different ($P < 0.05$).

Table 4 Effect of cage density and level of added fat on hen-day production (%).

	Cage density			
Level of added fat	4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	80.8 ± 1.0^{1ab}	84.5 ± 1.6^{2a}	83.3 ± 1.2^{a}	82.9 ± 1.4^{X}
3%	80.7 ± 1.7^{ab}	83.9 ± 2.9^{a}	82.0 ± 1.9^{ab}	82.2 ± 2.1^{X}
6%	77.0 ± 1.2^{b}	81.0 ± 1.2^{ab}	80.2 ± 1.2^{ab}	79.4 ± 1.4^{Y}
Average	79.5 ± 1.5^{A}	83.1 ± 2.0^{B}	81.9 ± 1.4^{AB}	

[1] Means of 4 replicates ±SE.
[2] Means without a common letter are significantly different ($P < 0.05$).

Table 5 Effect of cage density and level of added fat on hen-housed production (%).

Level of added fat	Cage density: 4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	76.4 ± 1.5^{bc}	81.2 ± 2.5^{ab}	83.3 ± 1.2^{a}	80.3 ± 2.2^{X}
3%	74.1 ± 0.9^{c}	82.7 ± 2.7^{a}	81.7 ± 2.1^{ab}	79.5 ± 2.7^{X}
6%	73.7 ± 1.0^{c}	80.4 ± 1.0^{ab}	78.8 ± 1.9^{abc}	77.6 ± 1.9^{X}
Average	74.7 ± 1.2^{A}	81.4 ± 2.1^{B}	81.3 ± 1.8^{B}	

[1] Means of 4 replicates ±SE.
[2] Means without a common letter are significantly different ($P < 0.05$).

Table 6 Effect of cage density and level of added fat on percent mortality.

Level of added fat	Cage density: 4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	16.7	6.3	0.0	7.7
3%	18.8	2.1	3.1	8.0
6%	12.5	2.1	3.1	5.9
Average	16.0	3.5	2.1	

When hens were fed the added fat rations, feed efficiency was significantly ($P < 0.01$) improved. However, feed efficiencies of hens fed the 3% or 6% added fat rations were not significantly ($P < 0.05$) different.

The effects of cage density and level of added fat on hen-day production and hen-housed production are presented in Tables 4 and 5, respectively. Egg production of hens provided with 310 cm^2/bird was significantly ($P < 0.05$) reduced. This reduction was dramatical when egg production was calculated on hen-housed basis. The increase in mortality among hens with floor space of 310 cm^2/bird, as shown in Table 6, was the

Table 7 Effect of cage density and level of added fat on egg weight (grams/egg).

Level of added fat	Cage density: 4 birds/cage 310 cm^2/bird	3 birds/cage 413 cm^2/bird	2 birds/cage 619 cm^2/bird	Average
0%	61.2 ± 0.9^{ab}	60.5 ± 0.6^{b}	61.2 ± 0.5^{ab}	61.0 ± 0.6^{X}
3%	61.5 ± 0.7^{ab}	61.1 ± 0.1^{ab}	61.6 ± 0.4^{ab}	61.4 ± 0.4^{X}
6%	62.4 ± 0.8^{a}	60.2 ± 0.3^{b}	61.8 ± 0.3^{ab}	61.5 ± 0.7^{X}
Average	61.7 ± 0.8^{A}	60.6 ± 0.4^{B}	61.6 ± 0.4^{A}	

[1] Means of 4 replicates ±SE.
[2] Means without a common letter are significantly different ($P < 0.05$).

reason for this dramatic reduction in hen-housed production. In fact mortality among this group of hens was 16% compared with 3.5 and 2.1% mortality among the other two groups (2 or 3 birds/cage). The addition of 6% fat to the ration resulted in slight, though not significant, drop in hen-housed production. But hen-day production of hens fed the 6% added fat ration was significantly ($P<0.05$) reduced.

The effect of cage density and level of added fat on egg weight is presented in Table 7. Analysis of variance showed that there was a barely significant ($P<0.05$) effect of cage density on egg weight. In fact the 'F' value was 3.38 compared to the tabulated 'F' value ($P<0.05$) of 3.35. However, this effect was not consistant. Eggs laid by hens provided with 310, 413 and 619 cm^2/bird had an average weight of 61.7, 60.6 and 61.6 g/egg, respectively. Ruszler and Quisenberry (9) found that when cage density increased, thus providing 290 cm^2/bird instead of 348 or 406 cm^2/bird, egg size tended to increase. Results of this experiment showed similar effect to that. However, when the floor space provided for each hen in this experiment was 619 cm^2, egg size was not decreased. Thus it would be difficult to confirm the findings of Ruszler and Quisenberry (9). Level of added fat had no effect on egg weight as shown in Table 7.

In general, the cumulative results of this experiment confirm the beneficial effects of fat addition to laying hen rations. There were indications that the maximum benefits from fat addition were at the 3% level rather than at the 6% level. Caged laying hens provided with 413 or 619 cm^2/bird performed equally well. Thus extra economical benefits from cage space utilization could be obtained.

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تأثير المساحة المتاحة للدجاج البياض في الأقفاص وكذلك كمية الدهن المضاف في العلف على إنتاجية دجاج البيض

فاروق حوراني

المستخلص

عملت هذه الدراسة على (٤٣٢) دجاجة بياضة بعمر (٢٤) أسبوع حيث قسمت إلى (٩) مجموعات بتوزيع إحصائي (٣×٣) حسب كمية الدهن المضاف في العلف (صفر و٣ و٦٪) وحسب المساحة المتاحة لكل دجاجة في القفص (٣١٠ و٤١٣ و٦١٩ سم٢) . ولقد كانت هناك (٤) مكررات لكل مستوى من مستويات المعاملتين . واستمرت التجربة لمدة (٢٥٢) يوما مقسمة لتسع (٩) فترات مدة الواحده منها (٢٨) يوما . ولقد كان للمعاملتين تأثيرات إحصائية مهمة على استهلاك العلف اليومى وعلى كفاءة تحويل العلف وعلى إنتاج البيض (على أساس عدد أيام الدجاج الحى) . كما كان للمساحة المتاحة لكل دجاجة في القفص تأثير إحصائي مهم على إنتاج البيض (على أساس عدد أيام الدجاج الأصلى) وكذلك على معدل وزن البيض الناتج . ولم يكن هناك أى تأثير إحصائي متداخل بين المعاملتين على أى من العوامل المتغيرة المدروسة . وبالنسبة للدجاج المتاح له مساحة ٣١٠ سم٢ لكل دجاجة فقد لوحظ نقص في إنتاج البيض وزيادة في استهلاك العلف ونقص في كفاءة تحويل العلف عن مثيله من الدجاج المتاح له مساحة ٤١٣ أو ٦١٩ سم٢ لكل دجاجة . ولقد كانت إنتاجية الدجاج المتاح له هاتين المساحتين (٤١٣ أو ٦١٩ سم٢ لكل دجاجة) متماثلة .