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INTRODUCTION

Culled laying pullets and hens constitute an important source of poultry meat in Hawaii. Certain ethnic groups are more inclined to purchase older hens than young broilers or fryers as sources of poultry meat.

Laying hens in Hawaii are housed under a variety of systems consisting of four major types; individual cages, colony cages, litter pens, and level-wire-floor pens. The colony cage system is an outgrowth of the individual cage system and has greatly increased in popularity in recent years. Litter

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pens, which previously had limited appeal to Hawaii's poultrymen, have been receiving increasing attention. The level-wire-floor system (including slatted floors) has also been in wide use in Hawaii. The predominant types, however, are still the individual and colony cage systems.

Several investigators have reported differences in live weight of laying hens maintained in different housing units, but there has been no report of carcass composition as influenced by differences in layer units. It was the intent of this investigation, therefore, to determine whether or not the different management systems influenced dressing percentages and carcass composition.

Bailey *et al.* (1959) reported significant differences in body weight between White Leghorn pullets maintained in individual cages and floor pens. In this test, Bailey and his associates found that pullets maintained in individual cages outweighed, on the average, those in litter pens by 116.4 grams. Pullets in the litter pens were allowed 3 square feet of floor area per bird. Yao (1959) found that White Leghorn pullets maintained on slatted floors at the rate of 1 square foot per bird weighed significantly less than those maintained on litter floors at the rate of 3 square feet per bird.

Palafox (1950) reported no significant difference in body weight between White Leghorn pullets maintained in wire-floor-layer units and individual cages, although those in the individual cages were, on the average, heavier.

Rosenberg and Tanaka (1952) found a significant difference in body weight between 18-month-old White Leghorn hens maintained on wire-floor pens and litter pens. The birds in the litter pens were significantly heavier.

EXPERIMENTAL PROCEDURE

A total of 174 laying hens of the University of Hawaii strain of New Hampshire chickens were used in this study. These hens had been in production for 44 weeks on a management study in which different systems of housing were compared. The management systems used included community laying cages of different sizes with sloping wire floors, level-wire-floor laying pens, and litter pens. A total of six community cages consisting of duplicate pens each measuring 2'X 8', 3'X 8', and 4'X 8' were used. The two level-wire-floor pens were 9'X 10', while the duplicate floor pens measured 6'X 17' and were covered with 6" of wood shavings. Space allowances were influenced by the number of birds available and the commonly accepted space requirement for heavy hens. The space allocation was approximately 1.6, 4.5, and 4.6 square feet per bird in colony cages, wire-floor pens, and litter pens, respectively. During the course of this study all experimental groups received the layer ration shown in table 1.

TABLE 1. Layer ration fed to all treatment groups

Ingredient	Pounds	Grams
Ground corn	65.0	
Soy bean oil meal (44%)	14.75	
Cane final molasses	7.0	
Alfalfa meal (dehydrated)	5.0	
Herring meal (70%)	4.5	
Defluorinated phosphate	3.0	
Iodized salt	0.5	
Manganese sulfate		6.0
Choline chloride [1]		100.0
Delsterol [2]		30.0
Niacin [3]		0.4
Riboflavin [3]		0.05
Thiamine hydrochloride [3]		0.06

[1] 25%.

[2] 3000 USP units Vitamin D_3 per gm.

[3] USP grade.

At the termination of the management study, all surviving hens were weighed. The hens were then slaughtered and weights were obtained after bleeding, defeathering, and evisceration. In addition, the combined liver, heart, and gizzard weights were obtained for each treatment group.

After evisceration, the birds were packaged in plastic bags and graded. Two grades were arbitrarily set up, Grade I and Grade II. Birds falling in Grade I were well-fleshed, well-bled, having full breast and "meaty" legs. They had no defects, such as a crooked breastbone, skin tear, or broken bones. Birds falling in Grade II were fairly well-fleshed and fairly well-bled. Slight deformities were permitted.

Nine birds from each treatment were then selected at random and frozen for analysis of carcass moisture, fat, protein, and ash, at a later date.

Prior to analysis, the partially defrosted eviscerated carcasses (less the liver, heart, and gizzard) were put through a power meat grinder several times and then mixed well before sampling. A representative sample was obtained from different parts of the ground chicken and mixed with an equal weight of finely ground silica. Duplicate samples were used for all determinations, and the carcasses analyzed at random, being identified only by number.

Carcass moisture was determined by drying a 4- to 5-gram sample in an oven at 135° C. for 4 hours. The dried sample was then extracted with anhydrous ether for 2 hours in a Goldfisch extraction apparatus. The resulting ether extract was weighed and the percent fat in the sample calculated.

The protein content was determined on the dried, ether-extracted residue. The ash content of the chicken sample was determined by ignition of the moist sample at 600° C. for 1 hour. The weight of the added silica was taken into consideration in all calculations. In addition, corrections were made on the basis of separate analyses made with silica.

The evisceration and carcass composition data were analyzed by means of the analysis of variance (Snedecor, 1956) and tests of significance by means of a multiple range test (Kramer, 1955).

RESULTS AND DISCUSSION

The experimental design of this experiment, as described earlier, introduced two variables: type of management (sloping wire floors, level wire floors, and litter pens), and space allowed per bird (1.6, 4.5, and 4.6 sq. ft. per bird, respectively). Generally speaking, such a design does not permit statements of one effect independent of the other since the effects are confounded. However, it will be noted that while the concentration of birds in the litter and level-wire-floor pens is essentially the same, the major difference between these two types of management system and the sloping-wire-floor pens, is in the amount of floor space allowed per bird. Therefore,

TABLE 2. Mean body weights, dressing losses, and grade of New Hampshire laying hens housed under different management systems

	Management System		
	Community cages	Litter pens	Level wire-floors
Space per bird, sq. ft.	1.6	4.6	4.5
Final body weight, gm.	3155 [a1]	2888 [b]	2693 [b]
Blood loss, %	2.5 [a]	2.8 [ab]	3.0 [b]
Blood and feather loss, %	6.1 [a]	7.1 [b]	7.2 [b]
Evisceration loss (from live weight), %	36.2 [a]	35.1 [a]	35.5 [a]
Evisceration loss (from New York dressed), %	32.1 [a]	30.3 [b]	30.5 [b]
Heart, liver, gizzard, % of live weight	5.1	5.4	5.8
Grade I, %	64	84	65

[1] Values in the same line with different alphabetical superscripts are significantly different from each other, $P<0.05$. Values without superscripts were not analyzed statistically.

while the main conclusion that may be reached would be attributed to the differences between community cages with 1.6 sq. ft. of space per bird and litter pens allowing 4.6 sq. ft. per bird and level-wire-floor cages having 4.5 sq. ft. per bird, it would appear from the data that the major effects observed were due to the concentration of birds per unit and only incidental to the type of pen or cage.

DRESSING LOSSES

It is interesting to note that the differences in final body weights and dressing losses as shown in table 2 are significantly greater between the community pen groups and the level-wire-floor groups, than between the level-wire-floor and the litter pens. This observation is all the more interesting since one would expect a closer relationship between hens reared in

TABLE 3. Mean carcass composition of New Hampshire laying hens housed under different management systems

Management system	Floor area per bird	Moisture	Fat	Protein	Ash
	sq. ft.	%	%	%	%
Community cages	1.6	55.2 [a1]	24.0 [a]	15.2 [a]	4.3 [a]
Level-wire floors	4.5	58.6 [b]	19.2 [a]	16.0 [a]	4.6 [a]
Litter pens	4.6	55.8 [a]	22.3 [a]	15.9 [a]	4.6 [a]

[1] Values in the same column with different alphabetical superscripts are significantly different from each other, $P<0.05$.

level-wire-floor pens and those reared in sloping-wire-floor pens (community cages) than between hens on level-wire-floors and litter pens.

It is therefore apparent that in this study the type of pen has less significance than the size of the respective pens. This is also true with respect to carcass composition as shown in table 3.

It is obvious from the data in table 2 that floor space affects final body weight: the smaller the space allowed per bird, the greater the body weight. This observation is in agreement with that of Bailey *et al.* (1959). This also would be related to the activity of the hens. When hens are allowed a small area, their activity is restricted and there is less opportunity to exercise. The more sedentary hens, therefore, tend to gain more weight. Although the hens in the wire-floor pens and the litter pens had a comparable amount of space, those in the wire-floor pens averaged almost ½ pound less than the hens on litter. This difference in final body size may be explained by the fact that the level-wire-floor pens were located in a much more exposed position on the research farm than either the community or the litter pens. Thus, the birds in those pens were subjected to considerably more vehicular traffic as well as pedestrian and animal traffic; which, no doubt, resulted in considerable increased activity of the hens in those pens.

Loss of blood during bleeding also appears related to floor space or, more likely, to the activity level. This might be explained on the basis of activity improving muscle tone which in turn allows for more complete

bleeding in the birds which had been more active. The difference in blood loss observed between the birds housed on litter and those on level-wire floors may be attributed to the greater activity necessary for the birds to balance on a wire floor than on litter.

The differences observed in percent feather loss are probably related to final body weight. Assuming an equal number of feathers on the hens in all groups, the fatter the hen the smaller the percent feather loss; and conversely, the thinner the hen the greater the percentage feather loss. Although of lesser significance, it is also possible that some of the difference in feather loss may be due to increased feather picking in the pens with less floor space per bird, although no case of cannibalism was noted throughout the management study.

The New York dressed weight expressed as percent of live weight was 93.96, 92.95, and 92.84 percent for the hens reared in community cages, litter pens, and level-wire-floors, respectively. These values compare favorably with those reported by Brown and Bean (1952) for White Leghorns and White Plymouth Rock hens of 91.2 and 91.1 percent, respectively.

Differences in evisceration loss may also be an indirect effect of the floor space allowance. The greatest evisceration loss was encountered in the community cage groups. Since these birds attained the greatest weights, and, because of their relative inactivity, the highest levels of carcass fat (see table 3), it is reasonable to infer that the greater evisceration loss is associated with the larger quantities of visceral fat.

CARCASS COMPOSITION

The differences in carcass composition shown in table 3 also reflect the influence of floor space and relative activity of the birds. The hens confined in community cages (1.6 sq. ft. per hen) had the highest level of carcass fat, while the most active birds in the level-wire-floor pens had the least fat. The differences in body fat observed also contribute substantially to the differences in final body weight noted in table 2.

The differences in carcass moisture are related to the body fat since there is an inverse relationship between body fat and body moisture. It is expected, therefore, that the group with the lowest carcass fat would have the highest body moisture, and the birds with the highest fat, the lowest moisture.

Carcass protein and ash also appear related to floor space with the groups on litter and in wire-floor pens having higher levels than the birds in community cages. It should be noted, however, that statistical significance was obtained only in the case of carcass moisture.

The only factor studied which appeared affected by litter management was the number of birds dressing out as Grade 1. While the percentage of birds in community cages and wire-floor pens graded No. 1 was 64 and 65 percent, respectively, 84 percent of the birds housed on litter were graded as number 1.

SUMMARY

Floor space allowed per laying hen (and related activity) appeared to be the predominant factor affecting final body weight, dressing losses, and carcass composition. Hens which had been confined to the least space (1.6 sq. ft. per bird) had the greatest final body weight, dressing losses, and carcass fat. All these factors appeared related to the increase in body fat. Hens allowed approximately 4.5 sq. ft. per bird, whether confined in level-wire-floor pens or on litter, showed a higher percentage blood and feather loss but lower fat and evisceration loss than birds confined in community pens with 1.6 sq. ft. per bird.

Evisceration loss from New York dressed hens averaged between 30.3 to 32.6 percent, while evisceration loss from live weight averaged between 35.1 to 36.3 percent.

The only factor studied which appeared affected by litter management was the carcass grade. Eighty-four percent of the birds housed on litter graded number 1, as compared to 64 and 65 percent of the hens confined to wire-floor pens.

On the basis of these results, it would appear that closely confined hens on wire will contain higher levels of body fat resulting in greater evisceration losses, and that birds reared on litter will generally yield carcasses of higher quality than hens confined in wire-floor pens.

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