Comparison between Laying Hen Performance in the Cage System and the Deep Litter System on a Diet Free from Animal Protein

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Abstract

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Battery cage systems for housing laying hens are being replaced by alternative systems including the deep litter system. At the same time, the substitution of meat and bone meal by vegetable matter in poultry feed mixtures is sought in the nutrition of laying hens. In the experiment, we compared the performance of laying hens of the ISA BROWN hybrid in both the cage system and the deep litter system, on a diet with the meat and bone meal content replaced by vegetable feeds (based on lupin). In the first group, 36 laying hens were kept in the deep litter system; in the second group, 36 laying hens were kept in cages. Over the period of nine months, the number of eggs laid, their weight, shell quality, the clinical state of the laying hens and incidence of their mortality were monitored daily. We found that in the cage system a higher number of eggs was obtained; a lower mean egg weight ($p < 0.01$); a higher number of eggs per hen per day ($p < 0.01$); a higher egg mass weight per hen per day ($p < 0.01$). There was a higher number of cracked eggs of the total number of eggs laid ($p < 0.01$), the number of membranous eggs of the total number of eggs laid did not differ ($p > 0.05$), and the number of laying hens which died was lower ($p < 0.05$) in comparison with the deep litter system. The results of the experiment demonstrate that, with the substitution of meat and bone meal by vegetable matter in the feed mixtures for laying hens, there are differences between the performance of laying hens from the deep litter system as compared to the laying hens from the cage system. The deep litter system better meets the requirements for the welfare of laying hens; however, it provides a lower yield.

Rearing technology, vegetable feeds, number of eggs, egg weight, cracked eggs, mortality

The traditional battery cage systems for the rearing of laying hens are being replaced by alternative systems to promote and increase laying hen welfare. Savory (2004) states that Council Directive 1999/74/EC laying down minimum standards for the protection of laying hens abolishes battery cage systems within the European Union from 2012. This Directive responds to public opinion requirements concerning the welfare of laying hens. However, scientific knowledge, in evaluating the battery cage system for laying hen rearing particularly in regard to production indicators, is not so unequivocal. This is due to the fact that the alternative systems often include higher risks to both the production and the health of laying hens. This is especially applicable to non-cage systems. The main issues requiring control in larger group floor housing are: parasitic disorders; the outbreak and spread of cannibalistic pecking; increased feed intake; misplaced eggs; the catching of spent hens; and air quality (Tauson 2005).

Duncan (2001) cites the advantages of the battery cage system. He regards as positive the low incidence of disease, the low incidence of social friction, and the absence of problems resulting from litter. As disadvantages, he cites: the lack of physical space for laying hens; the lack of space for daily activities and nesting; the absence of opportunities for dust-bathing; the higher incidence of foot lesions.

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Petermann (2003) found an increased incidence of mortality in alternative housing systems. De Boer and Cornelissen (2002) consider the battery cage system, particularly from the perspective of production and some health indicators, to be more beneficial than the aviary systems.

Changes relating to the diet of laying hens are being promoted in the present practice of rearing laying hens. The animal protein in poultry feed, provided by meat and bone meal, is being replaced by vegetable protein from selected vegetable products. Suchý et al. (2002) and Malá et al. (2004) described the replacement of animal protein by vegetable protein based on lupin in broilers. Hadorn et al. (2000) focused on the replacement of animal protein in the diet of laying hens.

The yield of laying hens, particularly in the number of eggs, can also be influenced by the incidence of mortality in laying hens. Petermann (2003) claims that the incidence of mortality in the deep litter systems, is high. Alternative systems, despite their benefit for welfare, thus encounter problems which remain unresolved.

Taylor and Hurnik (1996) compared the long-term performance of laying hens in the battery cage systems and aviary systems. They did not detect any evidential differences in egg weight, in the total daily egg production per hen, in the production of egg mass per hen per month and in the number of cracked eggs.

Vits et al. (2005) analysed the effect of furnished cages and two different small group systems on the production traits and egg quality traits of laying hens. The authors reported that the housing system and group size influenced egg production per hen, egg weight and the number of cracked eggs.

Tauson et al. (1999) studied the number of cracked eggs in the battery cage system and the aviary system. They discovered that the number of cracked eggs was lower in the aviary system in comparison with the battery cage system.

Abrahamsson and Tauson (1998) monitored the incidence of mortality in the rearing of laying hens. In the aviary system, they discovered a significant variation from 4.0 to 20.9% and explained this as the consequence of unpredictable cases of cannibalism. Sommer and Vasicek (2000) cite mortality in free-range poultry flocks at the level of 0 to 32%. Tauson et al. (1999) monitored the incidence of mortality in laying hens kept in cages and in laying hens kept in the aviary system. In laying hens in the aviary system, they detected mortality at the level of 21 to 27%, caused mainly in result of bacterial infections due to the pecking at naked skin by more aggressive laying hens. In the battery cage system, the mortality level did not exceed 7%. Similarly, Weitzenburger et al. (2005) reported that the incidence of mortality was greater in floor-reared laying hens than in the laying hens reared in conventional cages.

The aim of our study was to compare the performance of laying hens of ISA BROWN hybrid in both the cage and deep litter systems, on a diet with the meat and bone meal content replaced by vegetable feeds (based on lupin).

Materials and Methods

A comparison was made between the egg yields of laying hens kept in two rearing technologies: the deep litter system and the cage system, on the same level of nutrition without animal protein. 72 ISA BROWN hybrid laying hens were divided into two groups at the age of 16 weeks. The first group of 36 laying hens was kept in the deep litter system; the second group was kept in conventional cages for laying hens. The microclimate and lighting conditions for rearing followed the technological standard for the rearing of this hybrid. Feed mixtures N1 and N2, in which animal protein was replaced by vegetable protein based on lupin, were supplied *ad libitum* using automatic feeders. The composition of the feed mixtures N1 and N2 is provided in Table 1. Water was supplied *ad libitum* using automatic drinkers.

The experimental investigation, along with the collection of eggs, commenced at the 19th/20th week. The laying hens were observed for nine months (from 20 to 56 weeks of age). The number of eggs laid and their weight was monitored during this period on a daily basis. From the data collected, the mean egg weight, the mean number of eggs laid per hen per day, and the mean egg-mass production per hen per day were calculated monthly and then for the

Table 1. Component composition of feed mixtures (%)

Components	N1 Layers up to age 32 weeks	N2 Layers from age of 32 weeks onwards
Wheat	25.68	31.49
Corn	30.00	35.00
Soybean extracted meal	20.30	15.50
Proenergol (lupin)	10.00	6.00
Soybean oil	3.25	1.50
L – lysine monohydrochloride	0.14	0.15
Hydrosyanalog of methionine	0.26	0.20
L - threonine	0.05	0.06
Calcium carbonate coarse-grained	4.00	3.50
Calcium carbonate	4.20	4.90
Monocalcium phosphate	1.50	1.15
Sodium chloride	0.42	0.35
Aminovitan SK	0.20	0.20

entire period under review. In addition, the shell quality of eggs was observed, in particular the number of eggs that were cracked and the number that were membranous. From these data, the relative number of cracked and membranous eggs out of the total number of eggs was calculated monthly and then for the entire period under review.

The health status of the laying hens was monitored by clinical examination and the incidence of mortality in laying hens was recorded in the group in the deep litter system and in the group in the cage system over the entire period. The cause of death was determined by pathological-anatomical dissection.

The results were statistically processed using the statistical program *Unistat*, version 5.1. The mean values in the deep litter system group and in the cage system group were compared by an unpaired *t*-test; frequencies were compared using the χ^2 test.

Results

In the deep litter system and in the cage system, the number and mean weight of eggs were monitored monthly and over the entire period under review. The results are shown in Table 2. The table shows that the number of eggs was higher in the cage system, and that the egg weight was higher ($p < 0.01$) in the deep litter system.

Table 2. Number and mean egg weight in the deep litter system and in the cage system

	Deep litter			Cage			
Period	n	x (g)	sd (g)	n	x (g)	sd (g)	*p*
1st month	490	51.72	5.49	596	51.76	6.16	0.893
2nd month	954	60.45	6.47	958	58.09	5.52	0.000**
3rd month	844	62.83	6.01	938	59.85	5.23	0.000**
4th month	840	63.49	5.38	933	62.49	5.41	0.000**
5th month	690	64.84	5.05	846	63.61	5.30	0.000**
6th month	404	66.13	5.04	823	63.73	5.48	0.000**
7th month	353	67.43	4.59	810	65.04	5.30	0.000**
8th month	343	66.28	4.72	760	66.40	5.42	0.700
9th month	294	65.49	4.91	715	65.96	4.89	0.165
Total	5212	62.67	6.87	7379	62.00	6.74	0.000**

n = number of eggs, x = arithmetic mean, sd = standard deviation, *p* = statistical significance,

** = statistically highly significant ($p < 0.01$)

Calculation: x = sum of all egg weights / number of all eggs

Table 3. Mean egg number per hen per day in the deep litter system and in the cage system

Period	Deep litter		Cage		*p*
	x	sd	x	sd	
1st month	0.486	0.297	0.591	0.233	0.147
2nd month	0.946	0.052	0.950	0.059	0.792
3rd month	0.837	0.149	0.931	0.074	0.005**
4th month	0.833	0.185	0.926	0.081	0.021*
5th month	0.685	0.205	0.865	0.137	0.000**
6th month	0.463	0.154	0.919	0.100	0.000**
7th month	0.491	0.149	0.904	0.080	0.000**
8th month	0.490	0.100	0.848	0.087	0.000**
9th month	0.420	0.202	0.798	0.093	0.000**
Total	0.628	0.258	0.859	0.155	0.000**

x = arithmetic mean, sd = standard deviation, *p* = statistical significance, * = ($p < 0.05$), ** = ($p < 0.01$)
Calculation: x = number of eggs / sum of all daily numbers of hens in individual month

The results of mean egg numbers per hen per day are shown in Table 3. The table shows that the mean egg number per hen per day was significantly higher in the cage system.

On the basis of these data, the mean egg mass weight per hen per day was calculated. The results are shown in Table 4. The table shows that the mean egg mass weight per hen per day was significantly higher in the cage system.

Table 4. Mean egg mass weight per hen per day in the deep litter system and in the cage system

Period	Deep litter		Cage		*p*
	x (g)	sd (g)	x (g)	sd (g)	
1st month	25.14	16.295	30.61	13.411	0.176
2nd month	57.21	3.596	55.21	3.709	0.045*
3rd month	52.61	9.023	55.70	4.361	0.109
4th month	52.91	11.981	57.84	4.745	0.048*
5th month	44.38	13.169	54.98	8.822	0.001**
6th month	30.63	10.004	58.53	6.141	0.000**
7th month	33.14	9.850	58.80	5.345	0.000**
8th month	32.48	6.723	56.32	5.850	0.000**
9th month	27.51	13.283	52.64	6.311	0.000**
Total	39.56	15.893	53.40	10.834	0.000**

x = arithmetic mean, sd = standard deviation, *p* = statistical significance, * = ($p < 0.05$), ** = ($p < 0.01$)
Calculation: x = number of eggs * mean egg weight / sum of all daily numbers of hens in individual month

The results showing the number of cracked and membranous eggs out of the total number of eggs laid are shown in Table 5. The table shows that the number of cracked eggs was found to be higher ($p < 0.01$) in the cage system and the number of membranous eggs was higher in the cage system; however, this latter difference was not regarded as statistically significant.

The health status of the laying hens was observed by means of a clinical examination. No clinical change was recorded in the health status of the laying hens during the monitoring period. The incidence of mortality in the laying hens was recorded over the whole period in the deep litter system group and in the cage system group. The cause of death was established on the basis of pathological-anatomical dissection. There were cases of sudden death

Table 5. Number of cracked and membranous eggs in the deep litter system and in the cage system out of the total number of eggs laid

Period	Cracked			Membranous		
	Deep litter (%)	Cage (%)	*p*	Deep litter (%)	Cage (%)	*p*
1st month	3.06	5.03	0.105	1.02	1.68	0.356
2nd month	1.47	8.25	0.000**	0.84	0.94	0.814
3rd month	2.84	8.42	0.000**	0.00	0.21	0.180
4th month	0.95	5.79	0.000**	0.12	0.43	0.220
5th month	0.58	4.49	0.000**	0.00	0.24	0.201
6th month	1.73	3.28	0.121	0.00	0.12	0.483
7th month	1.70	6.17	0.001**	0.00	0.00	1.000
8th month	1.46	3.42	0.068	0.00	0.00	1.000
9th month	2.72	3.92	0.352	0.00	0.00	1.000
Total	1.75	5.57	0.000**	0.27	0.38	0.288

p = statistical significance, ** = ($p < 0.01$)

resulting from cannibalism. The number of dead laying hens per month and for the entire period under review is shown in Table 6. The results show a manifestation of cannibalism concentrated in the fifth and sixth months of the period under review. A statistically significantly higher incidence of mortality was detected in the deep litter system.

Table 6. Number of dead laying hens in the deep litter system and in the cage system

Period	Deep litter	Cage	*p*
1st month	0	0	1.000
2nd month	0	0	1.000
3rd month	0	0	1.000
4th month	0	0	1.000
5th month	0	4	0.040*
6th month	10	0	0.001**
7th month	1	0	0.263
8th month	0	0	1.000
9th month	0	0	1.000
Mean	1.2	0.4	-
Total	11	4	0.042*

p = statistical significance, * = ($p < 0.05$), ** = ($p < 0.01$)

Discussion

The housing of laying hens intended for egg production is changing at present; the traditional battery cage systems are being replaced by alternative systems, among which the deep litter systems are of great importance. Savory (2004) claims that this change is influenced rather by public opinion than by scientific knowledge. Duncan (2001) summarizes the advantages and disadvantages of the cage systems. Other authors, e.g. De Boer and Cornelissen (2002), Petermann (2003), Tauson (2005) etc. also document in their studies that the replacement of traditional battery cage systems by alternative systems does not always have an unambiguously positive impact on egg production, the health of laying hens and the incidence of mortality in laying hens.

Changes in the keeping of laying hens are also being brought about by another tendency: the replacement of animal protein in the diet of laying hens by vegetable protein. The results of experiments focusing on the replacement of meat and bone meal by vegetable feed in laying hens were described by Hadorn et al. (2000), and then in broilers by Suchý et al. (2002) and Malá et al. (2004).

In our study we investigated the impact on egg production of both developmental trends, i.e. the replacement of the battery cage system by the deep litter system and at the same time the change in the diet of laying hens, in which meat and bone meal was replaced by vegetable feeds based on lupin.

We discovered that the number of eggs obtained from laying hens in the deep litter system was lower than the number obtained from laying hens in the cage system. This was due, in part, to some eggs being mislaid outside the nests in the deep litter system. In addition, mislaid eggs are often damaged and broken and the number of laying hens is also decreased as a consequence of the higher incidence of mortality in the deep litter system. This effect has been manifested since the 3rd month. We can thus declare in accord with the opinion of Petermann (2003) that the alternative system has its problems, which are reflected in the number of eggs obtained from laying hens.

In our experiment, egg weight was found to be greater in the deep litter system than in the cage system. Similarly, Vits et al. (2005) reported a higher egg weight in floor-reared laying hens. Thus, we cannot endorse the results published by Taylor and Hurnik (1996), who, when comparing the performance of laying hens in battery cages and in aviaries, did not discover any substantial differences in egg weight.

The mean number of eggs per hen per day was found to be higher in the cage system, as well as the mean egg mass weight per hen per day. Taylor and Hurnik (1996), however, did not find any difference between the cage systems and the aviary systems in respect to these indicators.

In our experiment, the number of cracked eggs and membranous eggs was detected higher in the cage system. These results are in keeping with the findings of Tauson et al. (1999), who found a higher proportion of cracked eggs in the cage systems than in the floor ones. Taylor and Hurnik (1996), however, did not detect these differences in the incidence of shell-damaged eggs.

Manifestations of cannibalism were concentrated in the fifth and sixth months of the period under study and a higher incidence of mortality was recorded in the deep litter systems. The results confirm a higher incidence of mortality in the alternative systems and accord with the results published by the authors cited. Weitzenburger et al. (2005) reported a higher incidence of mortality in floor-reared laying hens than in laying hens reared in conventional cages. The authors indicated different types of cannibalism as the most common cause of death in laying hens. Abrahamsson and Tauson (1998) also refer to the high incidence of mortality in aviary systems, namely at a level of 4.0 - 20.9%, and Sommer and Vasicek (2000) at a level of 0 - 32%. Tauson et al. (1999) claim a mortality rate for aviary systems at a level of 21 - 27% and for battery cage systems at a level of 7%. In our experiment, the incidence of mortality corresponded to the level from the sources quoted; it was at 30.6% in the deep litter system and 11.1% in the cage system.

The results of the experiment prove that, in the diet with the substitution of meat and bone meal by vegetable matter in feed mixtures for laying hens, there are differences in the yield of laying hens in both the deep litter system and in the cage system. The deep litter system better meets the requirements for the welfare of laying hens; however, it is accompanied by a lower yield.

Porovnání užitkovosti nosnic v klecovém chovu a v chovu na hluboké podestýlce při výživě bez živočišné bílkoviny

Bateriové klecové chovy nosnic jsou nahrazovány chovy alternativními, mezi něž se řadí také voliérový chov nosnic na hluboké podestýlce. Současně se pro chovy nosnic hledá ve výživě vegetabilní náhrada za masokostní moučky v krmných směsích. V experimentu jsme porovnávali užitkovost nosnic ISA BROWN z klecového chovu a chovu voliérového na hluboké podestýlce, a to při výživě obsahující náhradu masokostní moučky vegetabilními krmivy (na bázi lupiny). V první skupině bylo 36 nosnic chovaných ve voliéře na hluboké podestýlce, v druhé skupině bylo 36 nosnic chovaných v klecích. Po dobu devíti měsíců byl denně sledován počet snesených vajec, jejich hmotnost, kvalita skořápky, klinický stav nosnic a úhyny nosnic. Zjistili jsme, že v klecovém chovu byl vyšší počet získaných vajec, nižší průměrná hmotnost vajec ($p < 0,01$), vyšší počet vajec na jednu slepici a na jeden den ($p < 0,01$), vyšší hmotnost vaječné hmoty na jednu slepici a na jeden den ($p < 0,01$), vyšší počet křapovitých vajec z celkového počtu snesených vajec ($p < 0,01$), nelišil se počet blanitých vajec z celkového počtu snesených vajec ($p > 0,05$), nižší byl počet uhynulých nosnic ($p < 0,05$) ve srovnání s voliérovým chovem nosnic na hluboké podestýlce. Výsledky experimentu prokazují, že při výživě nosnic s vegetabilní náhradou masokostních mouček v krmných směsích pro nosnice existují rozdíly v užitkovosti nosnic z voliérového chovu na hluboké podestýlce a nosnic z klecového chovu. Voliérový chov splňuje lépe požadavky na welfare nosnic, avšak je provázen nižší užitkovostí.

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