Effects of dietary energy content on the performance and laying traits of the breeder chukar partridge (*Alectoris chukar*) housed in battery cages or litter floor pens

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SUMMARY

In order to investigate the impact of environmental conditions on performance of game birds like partridges, the objective of this study is to explore the effects of dietary energy content and of 2 different housing conditions (battery cages vs. litter floor pen) on performance and laying traits in breeder chukar partridges. For that, 192 partridges, 36 weeks old at the beginning of experiment, were randomly allotted into 4 equal groups according to the housing type and the diet regimen [low energy (2 700 kcal/kg) or high energy (2 900 kcal/kg) diets] for 16 weeks using a 2x2 factorial arrangement. Weight variations, food intake and food efficiency, as well as reproductive traits (egg production, egg mass, egg weight, fertility and hatchability) were recorded for the whole experimental period. Except for the egg hatchability which was significantly increased when partridges have received a low energy diet whatever the rearing conditions, the housing type and the dietary energy level have not significantly affected the laying performance and no interaction between these 2 factors was evidenced. These results suggest that a ration with a low energy content respecting the nutrient recommended supplies can be distributed to partridges whatever the housing conditions and can also improved egg hatchability.

Keywords: Chukar partridge, housing type, dietary energy, performance, reproduction, egg production.

RÉSUMÉ

Effets de l'apport énergétique sur les performances et les caractéristiques de ponte des perdrix chukar (*Alectoris chukar*) élevées en batterie ou en enclos

Cette étude a été entreprise afin d'évaluer l'impact des conditions environnementales sur les performances des gibiers à plumes tels que les perdrix en explorant les effets de l'apport énergétique de la ration et de 2 types d'hébergement (cages métalliques vs. enclos avec litière) sur les performances et les caractéristiques de la ponte chez des perdrix d'élevage. Au total, 192 perdrix âgées initialement de 36 semaines ont été aléatoirement réparties en 4 groupes égaux en fonction des conditions d'hébergement et du régime alimentaire [faiblement (2 700 kcal/kg) ou fortement (2 900 kcal/kg) énergétique] pendant 16 semaines. Les variations pondérales, l'ingéré et l'efficacité alimentaires ainsi que les paramètres de reproduction (production en œufs, masse totale, poids des œufs, fertilité et éclosabilité) ont été mesurés pendant toute la durée de l'expérimentation. A l'exception de l'éclosabilité, significativement augmentée lorsque les perdrix recevaient une ration faiblement énergétique quelque soit les conditions d'élevage, ni le type d'hébergement ni le niveau énergétique de la ration n'ont affecté significativement les performances de ponte et aucune interaction entre ces 2 facteurs n'a été mise en évidence. Ces résultats suggèrent qu'une ration énergétiquement pauvre peut être distribuée aux perdrix quelque soit leurs conditions d'hébergement sans en diminuer les performances pourvu qu'elle respecte les recommandations en nutriments et qu'elle peut même améliorer l'éclosabilité des œufs.

Mots clés : Perdrix, type d'hébergement, énergie alimentaire, performance, reproduction, production en oeuf.

Introduction

The chukar partridge is one of the easiest game birds to rear in captivity. Although chukar partridges have been reared domestically for many years, they are still wild birds. Therefore, good management and nutrition are necessary to raise the birds successfully [29]. Because of little information about requirements of nutrients, environmental adaptations and breeding management, we are using information about other poultry, such as pheasant, wild turkey, quail, and laying hens [4]. However, these requirements may not be optimum for partridges. In addition, there is little published work on the interaction rearing type and diet on performance of partridges.

Production characteristics in farm animals are formed according to their genetic capacity and environmental factors. Management, feeding and type of housing are especially important among the environmental factors. Decreased cage space has been reported to lower egg production, egg weight and food intake and increase mortality [21]. The high animal density per unit area causes stress and lack of immunological response [1, 29]. The diet composition affects the performance of laying period for poultry. CAREW *et al*. [6] reported that increasing the dietary energy level of diet for white leghorn hens did not reverse the downward trend in egg production associated with decreased hen cage space. Also, dietary energy level affects egg production and egg weight in hens [8, 10]. WOODARD *et al.* [29] determined that energy requirement of game birds were given as 2 900 kcal/kg ME and

the same requirement was given in partridges [2, 7]. LECLERCQ *et al*. [15] recommended an energy requirement for partridges of 2 800 kcal/kg ME. JALAL *et al*. [13] reported that there was no interaction effects of ME levels on laying hen performance at varying cage space except for body weight change. Hens fed with 2900 kcal of ME/kg diet had significantly greater ME digestibility compared with those fed with 2800 or 2580 kcal of ME/kg, the differences being 107 and 118 kcal of ME/kg respectively. But, there were no observed significant effects of ME levels and no significant effects of cage space allowance on egg weight, hen weight, bone ash, or maintenance energy intake. JUNQUEIRA *et al*. [14] reported that different energy levels (2800, 2900 and 3050 kcal/kg ME) had not significantly effect on food intake, egg production, egg weight, egg mass and body weight change in layer hens.

Consequently, the purpose of this study was to determine the effects of dietary energy content on the performance and reproductive traits of the breeder chukar partridge reared in battery cages or litter floor pens.

Materials and Methods

EXPERIMENTAL ANIMALS AND REARING CONDITIONS

This study was carried out in the Farm of Agricultural Faculty of Selçuk University in Turkey. A total of 192 breeder chukar partridges (64 males, 128 females), 36 weeks old initially, were used in the study and were randomly divided in two groups, placed on litter floor pens or in wire battery cages in the same house and within a group, fed with either 2900 (high) or 2700 (low) kcal ME/kg diets through an egg production cycle. Four replicates of 12 birds each were constituted for evaluating the 4 treatments (2 housing types and 2 dietary energy levels) in 2x2 factorial arrangements. The diet composition (except for energy level) was formulated according to the recommendations of WOODARD *et al*. [29] (Table I).

The metal wired battery cage dimensions were 140 x 50 x 40 cm^3 equalling 7000 cm^2 total floor space with 12 birds (4 males, 8 females) per cage, each bird approximately having 600 cm^2 of floor space. The room dimensions of litter floor system were 56 m^2 and divided into 8 side cages using sheet wired (each cage dimensions were 3 x 2 x 2 m^3. The total floor space per cage were 6 m^2 with 12 birds (4 males, 8 females), each bird had approximately 5 000 cm^2 of floor space. Wood shaving as a litter material in the floor system was used. Water and feed were supplied *ad-libitum*. Initially, the birds were exposed to a 10-hour lighting period. After, the lighting period was increased by a quarter hour every day which was provided for 16 hours/day.

PERFORMANCE ANALYSIS

The partridges were weighed at the beginning and at the end of the experiment. Total duration of the experiment was 16 weeks. Hen day egg production, egg weight and food intake were recorded daily. Egg mass was calculated using the formula; Egg mass = [egg production (%) x egg weight (g)] / 100 and food conversion ratio was calculated by dividing food intake per bird and per day (g) by egg mass (g). Fertility and hatchability were determined from collected eggs at the 4th, 6th and 8th weeks of experiment. The eggs were incubated at 37.7°C and 65% relative humidity. After the 24 days long incubation period, the number of hatched chicks and unhatched eggs was recorded. Unhatched eggs were broken out and examined to determine the number of infertile eggs. Hatchability was calculated as hatchability of fertile eggs.

	High-ME (2 900 kcal/kg)	Low-ME (2 700 kcal/kg)
Ingredients (%)		
Corn	49.20	56.80
Soybean meal (40.8% CP)	24.40	23.50
Barley	9.33	6.50
Cottonseed meal	5.00	5.00
Vegetable Oil	4.00	---
Limestone	5.25	5.22
Di-calcium phosphate	1.85	1.90
Salt	0.50	0.50
Vitamin-mineral premix[1]	0.35	0.35
DL methionine	0.12	0.23
Calculated nutrients		
ME (kcal/kg)	2 904	2 700
CP (%)	17.02	17.04
Ca (%)	2.52	2.52
Available P (%)	0.45	0.46
Lysine (%)	0.81	0.84
Methionine (%)	0.40	0.41
Methionine + cystein (%)	0.70	0.71
Threonine (%)	0.64	0.64

CP: crude protein; ME: metabolizable energy; [1]Vitamin-mineral premix (/kg diet): Vitamin A, 12 000 IU; Vitamin D, 2 400 IU; Vitamin E, 25.0 mg; Vitamin K_3, 4.0 mg; Vitamin B_1 (thiamin), 3.0 mg; Vitamin B_2 (riboflavin), 5.0 mg; Vitamin B_6, 8.0 mg; Vitamin B_{12}, 0.015 mg; Niacin, 25.0 mg; Calcium-D-Pantothenate, 8.0 mg, D-Biotin, 0.05 mg; Folic acid, 0.5 mg; Choline Chloride, 125.0 mg; Mn, 80.0 mg; Fe, 60.0 mg; Zn, 60.0 mg; Cu, 5.0 mg; I, 1.0 mg; Co, 0.2 mg; Se, 0.15 mg.

TABLE I : Composition of diets distributed to breeder chukar partridge (36 - 52 weeks old).

STATISTICAL ANALYSIS

The experiment was designed as 2 (energy level) x 2 (breeding type) factorial within a randomized complete designs. A general linear model (GLM) was used for the analysis of variance of the data [16]. Significant differences among means were tested by Duncan's multiple range tests [17]. Percentage egg production was arcsine-transformed prior to analysis [28]. Differences were considered as significant when *P* value was less than 0.05.

Results

As shown in Table II, either the initial and final body weights or the laying period induced weight loss did not significantly differ between groups: the overall means of body weight changes were -22.4 ± 4.8 and -17.4 ± 6.8 g per bird for partridges receiving high energy dietary level and low energy dietary level respectively, whatever the housing conditions and -26.1 ± 9.2 and -13.6 ± 5.8 g per bird for birds rearing on litter floor pens and in battery cages respectively whatever the dietary energy level. In the same way, food intake and food conversion ration (FCR, expressed as kg of diet per g of egg) were not significantly affected by the metabolizable energy in diet or by the housing type; they were comprised between 31.2 ± 1.0 and 32.3 ± 0.8 g food/bird/day for food intake and between 7.33 ± 0.5 and 7.64 ± 0.7 g food/ g egg for food efficiency.

The laying performances of partridges and the fertility and hatchability of eggs are reported in the Table III. The energy supplied by the ration and the rearing conditions have not influenced the number of laying days and the egg production (in %). The egg weight and the egg mass were similar between groups and subgroups whatever the diet regimen or the housing conditions. In the same way, the percentages of egg fertility were closely related between groups although the highest values were recorded in the 2 subgroups fed with a low metabolizable energy diet. Finally, partridges fed with the low energy diet exhibited significantly higher egg hatchability than those fed with the high energy diet ($P < 0.01$) but this effect was independent of the housing conditions.

	IBW (g per bird)	FBW (g per bird)	ΔBW (g per bird)	Food intake (g/bird/day)	FCR (g food /g egg)
Housing type					
Litter floor pen (LFP)	512.3 ± 5.7	486.0 ± 5.5	-26.1 ± 9.2	32.3 ± 0.8	7.33 ± 0.5
Battery cage (BC)	505.0 ± 4.2	491.4 ± 5.5	-13.6 ± 5.8	31.2 ± 1.0	7.64 ± 0.7
Dietary energy level					
High (2 900 kcal/kg)	507.5 ± 4.8	485.1 ± 5.7	-22.4 ± 4.8	31.4 ± 0.5	7.50 ± 0.6
Low (2 700 kcal/kg)	509.8 ± 4.4	492.3 ± 5.2	-17.4 ± 6.8	32.1 ± 1.2	7.47 ± 0.7
Subgroups					
LFP x High ME	512.3 ± 9.5	481.8 ± 4.7	-30.5 ± 4.9	30.7 ± 0.5	7.39 ± 0.2
LFP x Low ME	512.3 ± 7.7	490.3 ± 6.6	-21.8 ± 9.3	33.9 ± 0.9	7.28 ± 1.0
BC x High ME	502.8 ± 7.2	488.5 ± 7.1	-14.3 ± 6.3	32.0 ± 0.7	7.62 ± 1.2
BC x Low ME	507.3 ± 5.3	494.3 ± 4.3	-13.0 ± 10.8	30.4 ± 2.0	7.66 ± 1.1

FVM: IBW: Initial body weight; FBW: final body weight; ΔBW: differences between final and initial body weights; FCR: Food conversion ratio: LFP: Litter floor pen; BC: battery cage; High ME: high dietary Metabolisable Energy (2 900 kcal/kg); Low ME: low dietary Metabolisable Energy (2 700 kcal/kg).

TABLE II : Effects of dietary energy level and housing conditions (litter floor pens vs. battery cages) on body weight, food intake and food conversion ratio in breeder chukar partridge (n = 48 in each subgroup) for 16 weeks. Results are expressed as means ± standard errors.

	Egg production		Egg weight	Egg mass	Fertility	Hatchability
	(day/bird)	%	(g egg)	(g egg/bird/day)	(%)	(%)
Housing type						
Litter floor pen (LFP)	23.8 ± 2.0	21.2 ± 1.8	21.1 ± 0.2	4.5 ± 0.4	88.41 ± 5.17	64.22 ± 10.86
Battery cage (BC)	23.2 ± 2.3	20.7 ± 2.0	21.1 ± 0.3	4.4 ± 0.4	87.57 ± 3.43	68.32 ± 8.90
Dietary energy level						
High (2 900 kcal/kg)	23.3 ± 1.7	20.8 ± 1.5	20.7 ± 0.2	4.3 ± 0.3	81.51 ± 5.24	44.29 ± 5.91[a]
Low (2 700 kcal/kg)	23.8 ± 2.5	21.2 ± 2.3	21.4 ± 0.3	4.5 ± 0.5	94.46 ± 1.50	88.24 ± 4.77[b]
Subgroups						
LFP x High ME	22.0 ± 0.8	19.6 ± 0.7	20.9 ± 0.3	4.1 ± 0.2	81.86 ± 9.52	35.96 ± 3.98
LFP x Low ME	25.6 ± 4.0	22.8 ± 3.5	21.2 ± 0.4	4.8 ± 0.7	94.96 ± 2.38	92.47 ± 1.55
BC x High ME	24.5 ± 3.3	21.9 ± 3.0	20.5 ± 0.2	4.5 ± 0.6	81.17 ± 5.32	52.62 ± 11.23
BC x Low ME	21.9 ± 3.4	19.5 ± 3.1	21.7 ± 0.3	4.2 ± 0.7	93.96 ± 2.18	84.01 ± 9.58

LFP: Litter floor pen; BC: battery cage; High ME: high dietary Metabolisable Energy (2 900 kcal/kg); Low ME: low dietary Metabolisable Energy (2 700 kcal/kg). Different superscripts a,b in the same column indicate significant differences (P < 0.01)

TABLE III : Effects of dietary energy level and housing conditions (litter floor pens vs. battery cages) on laying performance and egg qualities (fertility and hatchability) in breeder chukar partridge (n = 48 in each subgroup) for 16 weeks. Results are expressed as means ± standard errors.

Discussion

The present study observed that the housing type did not affect the performance and reproductive traits in chukar partridges and these results were in agreement with some other studies. GAUDIOSO *et al*. [9] reported that there were no differences in egg production (EP) between birds housed in closed or pen 4 m^2 cages. Studies in different European countries have shown that egg production in furnished cages was comparable with that in conventional cages [1, 22, 27]. Correspondingly, the present study confirmed reports that EP in floor pen system studied here was comparable with that in conventional battery cages. Our finding agree with those reported by BRAKE and PEEBLES [5] which found no effect of cage space on food intake in laying hens and VALKONEN *et al*. [25] observed no differences in FCR according to the cage types, although some researchers stated that FCR is poorer in free range systems than in cages [12, 26]. In alternative housing systems, hens have to use some of their energy for heat production [20] and movement, because of lower stocking densities and sometimes lower temperatures in these systems, leading to increases of the food intake and decreases of the food efficiency. Nevertheless, in the present experiment, these 2 parameters were not altered by the housing type.

On the other hand, the dietary energy levels did not affect the partridge performance as previously described in other poultry species. Indeed, it has been shown that the dietary energy supply did not influence weight variations [11, 14] or food intake [14, 18] in laying hens. However, conflicted results about laying performance were reported. According to HARMS *et al*. [11], egg production, egg weight and egg mass were not significantly modified by the dietary metabolizable energy. Similar results were reported by JALAL *et al*. [13] who found that the dietary energy level or the cage space did not significantly affect the egg weight of laying hens. But, NAHASHON *et al*. [18] observed significant increases of egg production, egg weight and egg mass in laying hens fed with a diet containing 2 800 kcal/kg ME compared to those fed with a 2 900 kcal/kg diet.

The most interesting result in the present study was that the partridges fed with the low energy diet exhibited significantly higher egg hatchability than those fed with the high energy diet ($P < 0.01$). Indeed, changes in yolk fatty acid composition linked to the lipid ration supply can alter the embryonic development. The yolk fat exerts a crucial role in avian embryonic development because it is a very important source of energy and essential nutrients. Hence, a significant alteration in yolk fatty acid composition could have drastic effects on embryonic survival [3]. Oleic acid (18:1 n-9) accounting for about 40% of total fatty acids in egg [19] is one of the major fatty acid in egg yolk and may play an essential role in the survival of avian embryos. TULLET [24] reported that the embryonic mortality in fertile eggs significantly increased when the oleic acid proportion of the total fatty acids in yolk failed below 40% whereas the stearic acid (18:0) proportion enhanced (> 12.5%) and when the ratio stearic acid / oleic acid exceeded 0.25. Additionally, in the present study, the partridges consumed a diet formulated from cereal grains and seeds, exceptionally rich in 18:2 n-6 but containing only minor amounts of n-3 fatty acids. Such a diet regimen is known to increase the proportions of n-6 fatty acids in phospholipids while reducing the proportions of n-3 polyunsaturated in all the egg lipid classes [23].

According to the present study, performance and reproductive characteristics were affected neither by the housing type nor the dietary energy level (except for hatchability) in chukar partridges. Moreover, no interaction between the housing type and the diet characteristics was observed. Consequently, a low energy diet (2 700 kcal/kg) containing the recommended nutrient amounts can be distributed to birds kept in battery cage or in litter floor pen. Besides, these results demonstrate that a high dietary energy may limit the hatchability in breeder chukar partridge. The evaluation of the effect of the fatty acid diet composition on hatchability was suggested for further studies.

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