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THE EFFECT OF REARING SYSTEM ON PLUMAGE QUALITY AND FOOT-PAD DERMATITIS IN GUINEA FOWLS AND PHEASANTS

Ahmet UÇAR[1]*, Mehmet Akif BOZ[2], Musa SARICA[3]

[1]Ankara University, Faculty of Agriculture, Department of Animal Science, 06110, Ankara, Türkiye
[2]Yozgat Bozok University, Faculty of Agriculture, Department of Animal Science, 66100, Yozgat, Türkiye
[3]Ondokuz Mayıs University, Faculty of Agriculture, Department of Animal Science, 55139, Samsun, Türkiye

Abstract: This study aims to determine welfare parameters such as foot-pad dermatitis (FPD) and plumage quality (PQ) scores at different slaughter ages in barn and free-range rearing systems for guinea fowl and pheasants. The birds randomly distributed with half of 200 Pheasant and 200 guinea fowl chicks were reared in both indoor and free-range systems. Game birds were examined for both FPD score and feather score (PQ) at 6, 12, 14, 16 and 18 weeks of age. The litter moisture content was also measured at 14, 16 and 18 weeks of the growing period. In guinea fowls, litter moisture content differed significantly according to the rearing system ($P<0.01$). In both game birds, gender differences were determined in wing feather quality for 6 weeks ($P>0.05$). In terms of FPD, there was no difference in guinea fowl according to the rearing system, gender and slaughter age, but there was a difference in pheasants according to the slaughter age. In guinea fowl, the head PART feather quality was lower than the barn system ($P<0.05$) and the lowest feather quality was found at 12 weeks of age in terms of slaughter age ($P<0.01$). It was determined that in terms of back, wing and tail feather quality of pheasants, those reared in closed system were lower ($P<0.01$). As a result, it was determined that guinea fowls had lower litter moisture in the free-range system, but this did not affect FPD score. On the other hand, it was found that FPD scores increased with age in pheasants. It was determined that free-range system was better in terms of head part feather quality in guinea fowls and back, wing and tail feathers were better in this system, similarly in pheasants. In terms of feather quality, a free-range system is recommended for better welfare for both species, especially pheasants.

Keywords: Game birds, Welfare, Rearing system, Pheasant, Guinea fowl

***Corresponding author:** Ankara University, Faculty of Agriculture, Department of Animal Science, 06110, Ankara, Türkiye
E mail: ucara@ankara.edu.tr (A. UÇAR)
Ahmet UÇAR https://orcid.org/0000-0002-0640-3965
Mehmet Akif BOZ https://orcid.org/0000-0002-7452-6895
Musa SARICA https://orcid.org/0000-0001-5331-0596

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1. Introduction

Although pheasants originate in Asia and guinea fowls in Africa, they spread to all continents due to their high adaptability. The breeding of game birds is a common practice in many European and American countries, and they make up a large proportion of game birds in these countries (Dahlgren, 1988; Nielsen, 2009; Jameel et al., 2022; Śmiecińska et al., 2022). These game birds are largely rearing in our country for the purpose of stocking the nature (Uçar and Sarıca, 2018). In some studies, data on the reproduction and growth performances of pheasants and guinea fowls were obtained and these studies give an idea about their potential (Yamak et al., 2016a; Yamak et al., 2018; Yamak et al., 2020; Boz et al., 2022). Welfare parameters such as PQ and FPD are important for the performance characteristics of poultry species. While most studies of poultry welfare have been conducted on broilers, laying hens and turkeys, studies on other species such as pheasants and guinea fowl are very limited (Nielsen, 2009).

FPD is characterized by necrotic and inflamed lesions ranging from superficial to deep on the surface of the foot-pad. Progressive deep inflammation can lead to chronic abscess and fibrosis of underlying structures (Greene et al., 1985). The thick epidermis of the foot-pad has a similar structure to scales, claws and beaks, but the keratin components of foot-pad are weaker and more sensitive due to thinner cell layers and the absence of keratin-bound calcium salts (Stettenheim, 1972). FPD is associated with decreased live weight and leg meat yield and increased carcass condemnations (Abraham et al., 2021). Factors such as ration content, litter type, stocking density, rearing system, age and litter moisture are also effective in FPD (Andrews and McPherson, 1963; Jensen et al., 1970; Harms et al., 1977; Dawkins et al., 2004; Bilgili et al., 2006; Buijs et al., 2009; Liebl et al., 2022).

The development of feathers in poultry is one of the most important physiological processes in the pre-breeding stage (Murphy, 1996). Naturally, chick plumage is such that it develops during the first weeks of life, while still under parental care ages. Feather structure is simpler in young birds because chicks often face a trade-off between investment in feather quality and rapid body growth (Butler et al., 2008). The higher PQ is likely to

increase thermoregulation and flight capabilities (Nilsson and Svensson, 1996; Swaddle et al., 1996). Factors similar to those that affect FPD affect PQ, and in addition, feather pecking is the most important factor in PQ (Brunberg et al., 2011; Bennewitz et al., 2014). When raising poultry species such as pheasants and guinea fowl in captivity or in large numbers in a field, the main obstacle is initiation of harmful pecking, which leads to a decline in their welfare (Rodenburg et al., 2013; Jensen, 2018). This causes serious economic losses on many farms (Draycott et al., 2002; Draycott et al., 2005). The main factor affecting harmful pecking in game birds is the size of rearing area (Kjaer, 2004). The smaller size of the group and the use of traditional and furnished cages are associated with lower levels of harmful pecking compared to the larger bird groups typical of free-range systems (Zimmerman et al., 2006; Lay Jr et al., 2011). Ranging outside for a longer period of time with free access severely reduces harmful pecking in birds (Bestman and Wagenaar, 2003; Leone et al., 2010). There is a difference in PQ between the sexes and a higher pecking was observed in male pheasant flocks (Zapletal et al., 2011). Various studies suggest that feather pecking in different rearing systems for poultry species will decrease if they are encouraged by foraging on the litter, grass-straw hanging from perforated baskets, or other objects that can be pecked (Homeyer, 1969; Nørgaard-Nielsen et al., 1993; Channing, 1998; Huber-Eicher and Wechsler, 1998; Wechsler and Huber-Eicher, 1998; Colton and Fraley, 2014; Coton et al., 2019).

There are many studies on FPD and PQ in species such as chicken and turkey, especially in broilers, but since the number of such studies is low in species such as pheasant and guinea fowl, our study is important in terms of being to the literature. This study aims to determine welfare parameters such as FPD and PQ scores at different slaughter ages in Barn and Free-Range Rearing Systems for Guinea Fowl and Pheasants.

2. Materials and Methods

2.1. Animal Material

All procedures were approved by the Ondokuz Mayis University Ethical Committee for Experimental Animals. Guinea fowl eggs were collected from the flock reared at the Turkish Ministry of Agriculture and Forestry Yozgat Breeding Station, and 200 day-old Guinea fowl keets were randomly selected for use in the experiment. Pheasant (*Phasianus colchicus*) eggs were collected from a flock reared at the Turkish Ministry of Agriculture and Forestry Samsun Breeding Station, and 200 day-old Pheasant chicks were randomly selected for use in the experiment.

2.2. Rearing System and Conditions

Guinea fowl keets were randomly allocated to pens belonging to either an indoor ("barn") or outdoor-access ("free-range") production system that was interspersed within windowed houses, with 4 pens per system and 25 keets per pen. Groups were formed in the same way in pheasant chicks. Pens (3.5 × 3.5 m) were separated and covered by 0.5 × 0.5 cm wire mesh to prevent birds from flying between pens. Each pen contained one round feeder and one round drinker. The indoor pen also contained an 8-cm layer of wood shavings used as litter, and no fresh litter was added during the production period. Heating was provided by infrared heaters, and economic white bulbs were used for lighting. A 24-hour light regime was applied during the first 3 days. Light was incrementally decreased to 20 h over d 3 to 14 and then remained constant until 6 wk, after which natural lighting (app. 14 h/d) was applied until slaughter. After 6 wk of age, birds in the outdoor free-range system were given 24-hour access to outdoor pens measuring 14 × 3.5 m through a single doorway measuring 50 × 90 cm. All birds were fed *ad libitum* with the same commercial layer chicken diet based on corn and soybean meal until 12 wk of age (19% Crude Protein and 11.72 MJ/kg Metabolisable Energy) and with layer chicken developer diet from 12 wk until the end of the experiment (16% Crude Protein and 11.30 MJ/kg Metabolisable Energy).

2.3. Litter Moisture

Litter moisture content was measured at Weeks 14, 16 and 18 using samples collected from 5 different points in each pen. Samples were oven-dried at 105°C until weight-loss stability was achieved, and dry matter (%) was recorded (Sarıca and Çam, 1998).

2.4. Plumage Quality (PQ)

Feathers of all pheasant and guinea fowls were scored individually at 6 weeks and slaughter ages of 12, 14, 16 and 18 weeks, with scores obtained from six (head, neck, breast, back, wings and tail) body parts (Yamak and Sarica, 2012) using a 4-point scoring system to rate plumage conditions, as follows: 4 = completely protected by feathers; 3 = local deterioration (up to 1/3 loss);2 = significant deterioration (between 1/3 to ½ loss) and 1 = bare skin (Tauson et al., 1984). First feather-change (moult) was also noted. The feather score was made as an indicator of PQ.

2.5. Foot pad Dermatitis (FPD)

FPD of all pheasant and guinea fowls were scored individually at 6 weeks and slaughter ages of 12, 14, 16 and 18 weeks. FPD incidence was evaluated on both left and right foot pads and webs using a 4-point scale, as follows: 0 = no lesions; 1 = lesions on < 25% of pads; 2 = lesions on 25%-50% of pads; 3 = lesions on 50%-75% of pads; 4 = lesions on > 75% of pads (Sarica and Yamak, 2010). FPD scores for pads and webs as well as total FPD scores are also given.

2.6. Statistical Analysis

Analysis of variance (ANOVA) was used to evaluate data. Factorial variance analysis of FPD scores and PQ, rearing system, age and gender was performed using the non-parametric Friedman's Test, with Kruskal-Wallis testing conducted for traits whose interactions were found significant. Differences among groups were examined using Duncan's multiple comparison test. All data analysis was performed using SPSS Software Version

20.0 licensed to Ondokuz Mayis University (SPSS Inc., Chicago, IL, USA).

3. Results

In guinea fowls, litter moisture content, or litter dry matter content, differed significantly according to the rearing system (P<0.01). However, no relationship was found between slaughter age and litter content (Table 1). Although a difference was found between rearing system and litter moisture content in guinea fowls, no difference was found in pheasants. Again, slaughter age was not effective on litter content in pheasants, similar to guinea fowls (Table 2).

General averages of FPD and PQ scores were given for guinea fowls (Table 3) and pheasants (Table 4) by sex, as they were reared in a barn system at the first 6 weeks of age. In both game birds, gender differences were determined in wing feather quality (P>0.05). Although the wing part feather quality score of males was found to be better in guinea fowls, it was found to be lower in male pheasants.

Effect of rearing system and slaughter age on FPD in Guinea Fowls and Pheasants are shown in Table 5 and Table 6, respectively. In terms of FPD, there was no difference in guinea fowl according to the rearing system, gender and slaughter age, but there was a difference in pheasants according to the slaughter age (FPD score increased as the slaughter age increased).

Table 1. Litter moisture content of guinea fowls at different rearing system and ages

Rearing System	Age (Week)	Moisture	Dry Matter
		%	
	14	11.63	88.37
FR	16	12.76	87.23
	18	12.79	87.21
	14	13.90	86.10
IN	16	14.20	85.80
	18	14.46	85.54
SEM		0.264	0.264
Effects			
Rearing System		**	**
FR		12.39[b]	87.61[a]
IN		14.18[a]	85.81[b]
Age		NS	NS
14		12.76	87.23
16		13.48	86.52
18		13.62	86.38
Rearing System x Age		NS	NS

FR= free-range system; IN= indoor system; SEM= standart error of mean; **= P<0.01.

Table 2. Litter moisture content of pheasants at different rearing system and ages

Rearing System	Age (Week)	Moisture	Dry Matter
		%	
	14	12.81	87.19
FR	16	15.72	84.28
	18	13.23	86.78
	14	14.02	85.98
IN	16	13.35	86.65
	18	14.82	85.18
SEM		0.474	0.474
Effects			
Rearing System		NS	NS
FR		13.92	86.08
IN		14.06	85.94
Age		NS	NS
14		13.42	86.58
16		14.53	85.47
18		14.02	85.97
Rearing System x Age		NS	NS

FR= free-range system; IN= indoor system; SEM= standart error of mean; ** P<0.01.

Table 3. FPD and PQ at week 6 in Guinea fowls [X±Sx (med:min-max)]

		PQ					
Gender	FPD	Head	Neck	Back	Wing	Tail	Breast
Male	0±0 (0:0-0)	4±0 (4:4-4)	4±0 (4:4-4)	3.93±0.24 (4:3-4)	3.76±0.04 (4:3-4)[a]	3.96±0.02 (4:3-4)	3.97±0.02 (4:3-4)
Female	0±0 (0:0-0)	4±0 (4:4-4)	4±0 (4:4-4)	3.90±0.03 (4:3-4)	3.62±0.10 (4:3-4)[b]	3.98±0.02 (4:3-4)	3.95±0.03 (4:2-4)
P	NS	NS	NS	NS	*	NS	NS

* P<0.05.

Table 4. FPD and PQ at week 6 in Pheasants [X±Sx (med:min-max)]

		PQ					
Gender	FPD	Head	Neck	Back	Wing	Tail	Breast
Male	0±0 (0:0-0)	0±0 (0:0-0)	0±0 (0:0-0)	2.59±0.13 (3:1-4)	3.32±0.06 (4:3-4)[b]	3.85±0.04 (4:3-4)	3.98±0.01 (4:3-4)
Female	0±0 (0:0-0)	0±0 (0:0-0)	0±0 (0:0-0)	2.63±0.14 (3:1-4)	3.49±0.06 (4:3-4)[a]	3.89±0.04 (4:3-4)	4±0 (4:4-4)
P	NS	NS	NS	NS	*	NS	NS

* P<0.05.

Table 5. Effect of rearing system and slaughter age on FPD in Guinea fowls [X±Sx (med:min-max)]

Rearing System	Slaughter Age (Week)	Gender	FPD
Free-Range	12	Male	0±0 (0-0)
		Female	0.03±0,02 (0:0-1)
	14	Male	0.03±0,02 (0:0-1)
		Female	0±0 (0:0-0)
	16	Male	0.02±0,02 (0:0-1)
		Female	0±0 (0:0-0)
	18	Male	0.06±0,03 (0:0-1)
		Female	0±0 (0:0-0)
Indoor	12	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	14	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	16	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	18	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
Effects			
Rearing System			NS
		Free-range	0.02±0.01 (0:0-1)
		Indoor	0±0 (0:0-0)
Slaughter Age			NS
		12	0,01±0.01 (0:0-1)
		14	0.01±0.01 (0:0-1)
		16	0.01±0.01 (0:0-1)
		18	0.03±0.02 (0:0-1)
Gender			NS
		Male	0.02±0.01 (0:0-1)
		Female	0.01±0.01 (0:0-1)
Rearing System x Slaughter Age			NS
Rearing System x Gender			NS
Slaughter Age x Gender			NS
Rearing System x Slaughter Age x Gender			NS

Table 6. Effect of rearing system and slaughter age on FPD in Pheasants [X±Sx (med:min-max)]

Rearing System	Slaughter Age (Week)	Gender	FPD
Free-Range	12	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	14	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	16	Male	0.04±0.04 (0:0-1)
		Female	0.04±0.04 (0:0-1)
	18	Male	0.10±0.07 (0:0-1)
		Female	0.06±0.05 (0:0-1)
Indoor	12	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	14	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	16	Male	0±0 (0:0-0)
		Female	0±0 (0:0-0)
	18	Male	0.06±0.04 (0:0-1)
		Female	0±0 (0:0-0)
Effects			
Rearing System			NS
	Free-range		0.03±0.01 (0:0-1)
	Indoor		0.01±0.01 (0:0-1)
Slaughter Age			**
	12		0±0 (0:0-0)[a]
	14		0±0 (0:0-0)[a]
	16		0.02±0.01 (0:0-1)[a]
	18		0.05±0.02 (0:0-1)[b]
Gender			NS
	Male		0.02±0,01 (0:0-1)
	Female		0.01±0,01(0:0-1)
Rearing System x Slaughter Age			NS
Rearing System x Gender			NS
Slaughter Age x Gender			NS
Rearing System x Slaughter Age x Gender			NS

** P<0.01.

Effect of rearing system and slaughter age on PQ in Guinea Fowls and Pheasants are shown in Table 7 and Table 8, respectively. In guinea fowl, the head area feather quality was lower than the barn system (P<0.05) and the lowest feather quality was found at 12 weeks of age in terms of slaughter age (P<0.01). There was an interaction between head feather quality, rearing system and slaughter age (P<0.01), and slaughter age and gender (P<0.05). It was determined that in terms of back, wing and tail feather quality of pheasants, those reared in closed system were lower (P<0.01). It was determined that the feathering of the dorsal part differed according to the slaughter age and the females had lower feather quality in this part (P<0.01). In terms of back feathering, interaction (P<0.05) was determined between rearing system and slaughter age and rearing system and gender.

Table 7. Effect of rearing system and slaughter age on PQ in Guinea fowls [X±Sx (med:min-max)]

RS	SA	G	Head	Neck	Back	Wing	Tail	Breast
FR	12	M	3.96±0,02 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	3.95±0,04 (4:3-4)	3.97±0,03 (4:3-4)	3.97±0,03 (4:3-4)	3.97±0,03 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)
	14	M	4±0 (4:4-4)	3.98±0,02 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	3.97±0,03 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	16	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	18	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
IN	12	M	3.90±0,06 (4:2-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	3.67±0,01 (4:1-4)	3.92±0,06 (4:2-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	14	M	4±0 (4:4-4)	3.98±0,02 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	3.98±0,02 (4.3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	16	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	18	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
Rearing System			*	NS	NS	NS	NS	NS
	FR		3.99±0,01 (4:3-4)[a]	3.99±0,01 (4:3-4)	3.99±0,01 (4:3-4)	3.99±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)
	IN		3.93±0,02 (4:3-4)[b]	3.98±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
Slaughter Age			**	NS	NS	NS	NS	NS
	12		3.87±0,03 (4:3-4)[a]	3.97±0,03 (4:1-4)	3.99±0,01 (4:3-4)	3.98±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)
	14		4±0 (4:4-4)[b]	3.97±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	16		4±0 (4:4-4)[b]	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	18		4±0 (4:4-4)[b]	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
Gender			*	NS	NS	NS	NS	NS
	Male		3.98±0,01 (4:2-4)	3.99±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	Female		3.93±0,02 (4:1-4)	3.97±0,01 (4:2-4)	3.99±0,01 (4:3-4)	3.99±0,01 (4:3-4)	4±0 (4:4-4)	4±0 (4:4-4)
RS x SA			**	NS	NS	NS	NS	NS
RS x G			NS	NS	NS	NS	NS	NS
SA x G			*	NS	NS	NS	NS	NS
RS x SA x G			NS	NS	NS	NS	NS	NS

RS= rearing system; SA= slaugter age; G= gender; M= male; F= female; FR= free-range; IN= indoor, **= P<0.01, *= P<0.05.

Table 8. Effect of rearing system and slaughter age on PQ in Pheasants [X±Sx (med:min-max)]

RS	SA	G	Head	Neck	Back	Wing	Tail	Breast
FR	12	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	14	M	4±0 (4:4-4)	4±0 (4:4-4)	3.89±0,06 (4:3-4)	4±0 (4:4-4)	3.96±0.03 (4:3-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	16	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
	18	M	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)	4±0 (4:4-4)
IN	12	M	4±0 (4:4-4)	4±0 (4:4-4)	3.35±0.15 (4:1-4)	3.97±0.02 (4:3-4)	2.95±0.19 (3:1-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	3.55±0.12 (4:1-4)	4±0 (4:4-4)	2.80±0.19 (3:1-4	4±0 (4:4-4)
	14	M	4±0 (4:4-4)	4±0 (4:4-4)	3.23±0.09 (3:2-4)	3.95±0.04 (4:3-4)	2.97±0.16 (3:1-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	3.46±0.12 (4:1-4)	3.95±0.03 (4:3-4)	2.71±0.16 (3:1-4)	4±0 (4:4-4)
	16	M	4±0 (4:4-4)	4±0 (4:4-4)	3.61±0.09 (4:2-4)	3.94±0.04 (4:3-4)	3.30±0.14 (4:2-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	3.80±0.08 (4:2-4)	4±0 (4:4-4)	3.14±0.15 (3:1-4)	4±0 (4:4-4)
	18	M	4±0 (4:4-4)	4±0 (4:4-4)	3.56±0.10 (4:2-4)	3.97±0.03 (4:3-4)	3.03±0.16 (3:1-4)	4±0 (4:4-4)
		F	4±0 (4:4-4)	4±0 (4:4-4)	3.78±0.09 (4:2-4)	4±0 (4:4-4)	2.97±0.17 (3:1-4)	4±0 (4:4-4)
Rearing System			NS	NS	**	**	**	NS
	FR		4±0 (4:4-4)	4±0 (4:4-4)	3.98±0,01 (4:3-4)^{a}	4±0 (4:4-4)^{a}	3.99±0,01 (4:3-4)^{a}	4±0 (4:4-4)
	IN		4±0 (4:4-4)	4±0 (4:4-4)	3.53±0,04 (4:1-4)^{b}	3.97±0,01 (4:3-4)^{b}	2,97±0.06 (3:1-4)^{b}	4±0 (4:4-4)
Slaughter Age			NS	NS	**	NS	NS	NS
	12		4±0 (4:4-4)	4±0 (4:4-4)	3.67±0,06 (4:1-4) ^{ab}	3.99±0,07 (4:3-4)	3.33±0.09 (4:1-4)	4±0 (4:4-4)
	14		4±0 (4:4-4)	4±0 (4:4-4)	3.59±0,05 (4:1-4) ^{a}	3.97±0,01 (4:3-4)	3.30±0.08 (4:1-4)	4±0 (4:4-4)
	16		4±0 (4:4-4)	4±0 (4:4-4)	3.82±0,04 (4:2-4) ^{c}	3.98±0,01 (4:3-4)	3.52±0.07 (4:1-49	4±0 (4:4-4)
	18		4±0 (4:4-4)	4±0 (4:4-4)	3.79±0,04 (4:2-4) ^{bc}	3.99±0,01 (4:3-4)	3.37±0,09 (4:1-4)	4±0 (4:4-4)
Gender			NS	NS	**	NS	NS	NS
	Male		4±0 (4:4-4)	4±0 (4:4-4)	3.46±0,04 (4:1-4)^{b}	3.98±0,01 (4:3-4)	3.43±0,06 (4:1-4)	4±0 (4:4-4)
	Female		4±0 (4:4-4)	4±0 (4:4-4)	3.78±0,03 (4:1-4)^{a}	3.99±0,06 (4:3-4)	3.32±0,06 (4:1-4)	4±0 (4:4-4)
RS x SA			NS	NS	*	NS	NS	NS
RS x G			NS	NS	*	NS	NS	NS
SA x G			NS	NS	NS	NS	NS	NS
RS x SA x G			NS	NS	NS	NS	NS	NS

RS= rearing system; SA= slaugter age; G= gender; M= male; F= female; FR= free-range; IN= indoor, **= P<0.01, *= P<0.05.

4. Discussion

Ammonia evaporation from litter in poultry houses varies depending on the moisture and temperature content of the litter. As the temperature and humidity increase, ammonia release from the litter also increases (Miles et al., 2011). Ammonia emissions are known to be very sensitive to litter moisture content (Liu et al., 2007). The high release of ammonia from the litter causes irritation to the respiratory tract and skin in birds, but also causes foot-pad dermatitis, hock burns and breast blisters (Nairn and Watson, 1972; Martland, 1984; Nauaraj et al., 2006; Youssef et al., 2011). The litter content is an important factor affecting not only the FPD but also the feather (especially breast and abdomen area)

quality (Terčič et al., 2015). In our study, especially in guinea fowls, the litter moisture was found to be higher in the barn system than in the free-range system.

But this difference in moisture content was not reflected in FPD scores. It is reported that the amount of ammonia increases with the reused litter, and as a result, the FPD rates increase (Yamak, et al., 2016b), but this problem will disappear with adequate ventilation (Dawkins, et al., 2004). In a study on turkeys, it is emphasized that litter moisture should be kept below 30% to reduce the risk of FPD (Wu and Hocking, 2011). In our study, the fact that the litter moisture was quite low in both rearing systems explains the good FPD scores and the lack of difference between the systems (Table 1 and 2).

In a study conducted in broiler chickens, it was reported that litter moisture and FPD ratios increased as the fattening time increased (Eichner et al., 2007). In a study conducted in turkeys, it was stated that litter moisture is highly effective in causing FPD and it causes inflammation in young turkeys in a very short time, but the exact mechanism by which this occurs is unknown. Therefore, wet litter control is likely to be highly effective in reducing the severity and prevalence of FPD in commercial poultry flocks (Mayne et al., 2007). Because litter moisture is crucial to the control of FPD, a multifactorial approach to litter management will be necessary to strike a balance with the many other factors involved in poultry management (Taira et al., 2014). In a study about broilers, estimated prevalence of FPD ranged from 9.6 to 98.1% depending on the housing system used. Flocks with outdoor access (free-range and organic systems) have been reported to have a higher prevalence of FPD than those kept in completely enclosed systems (Pagazaurtundua and Warriss, 2006). In a study on geese, the incidence of FPD decreases when the animals are provided with a swimming pool (Liao et al., 2021). In another study on ducks, it is reported that the presence of a pool has a positive effect on foot pad cleaning and feather quality, similar to geese (Jones and Dawkins, 2010). In a study on turkeys, similar to our findings in guinea fowls, it was reported that the litter moisture was lower in the free-range system and accordingly, the FPD level was lower in the free-range system (Sarica and Yamak, 2010). However, according to our study results, it was determined that the rearing system did not affect FPD in both pheasants and guinea fowls (Table 5 and 6). FPD should be seen as an important animal welfare issue. Considering today's both traditional and organic poultry farming systems, it does not seem possible to completely prevent the formation of footpad lesions (Freihold et al., 2019). It is known that FPD severity increases with age in poultry species (Shepherd and Fairchild, 2010). However, in our study, while slaughter age and FPD score did not change in guinea fowls, FPD score increased as slaughter age increased in pheasants, similar to the literature.

Harmful feather pecking and cannibalism can have a serious impact on feather quality and therefore bird welfare (Petek et al., 2015). Genetics and age are known to be important factors in feather pecking. In addition, the most common causes are boredom, high light intensity, low humidity, restricted nutrition and perhaps nutritional deficiencies (Leeson and Walsh, 2004). Guinea Fowl and Pheasants attain their first young plumage at 4-5 weeks of age, and in especially pheasants at 20 weeks young males reach plumage that is almost unnoticeable from adult males (Westerskov, 1955). According to the results we obtained from guinea pigs, it is seen that they have the lowest feather score at the age of 12 weeks since the feather cover is not fully developed yet in terms of head area feathering (Table 7). Also, in terms of feathering in this part, it was determined that reared in the free-range system and male guinea fowls had better PQ than the barn system and females. In pheasants, unlike guinea fowls, females had a better feather score in terms of back feathering (Table 8). Again, it was observed that the feathers of this area were irregular but significantly different according to slaughter age. In terms of feathering in the back, wing and tail parts, it was determined that those reared in the free-range system had higher scores as in the guinea fowls. Similar to our study findings, Boz et al. (2017) also reported that geese reared in the free system were better in terms of wing and tail feathering. In a study on laying hens, it was reported that as the area per animal increases, both the feather quality and the yield are better (Sarica et al., 2008). In our study, it can be said that animals have a better PQ compared to the barn system, since they have more space in the free-range system and feel less boredom.

5. Conclusion

As a result, it was determined that guinea fowls had lower litter moisture in the free-range system, but this did not affect FPD score. On the other hand, it was found that FPD scores increased with age in pheasants. It was determined that free-range system was better in terms of head part feather quality in guinea fowls and back, wing and tail feathers were better in this system, similarly in pheasants. In terms of feather quality, a free-range system is recommended for better welfare for both species, especially pheasants.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	A.U.	M.A.B.	M.S.
C	30	40	30
D	30	30	40
S			100
DCP	40	40	20
DAI	40	40	20
L	60	30	10
W	50	30	20
CR	10	40	50
SR	80	20	
PM	10	60	30
FA	10	20	70

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

The experiment was conducted between May and August 2015 at the Ondokuz Mayis University Agricultural Faculty's Research Farm, Turkey. All procedures were approved by the Ondokuz Mayis University Ethical Committee for Experimental Animals (protocol code: 2015/55 and date: May 15, 2015). This study was conducted using material from previously published studies (Yamak et al., 2018; 2020).

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