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Impact of environmental enrichment on the productivity of Japanese quails

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SUMMARY

The aim of this study was to evaluate the production parameters and egg quality of Japanese quail (*Coturnix japonica*) as a possible response to enrichment of the birds' cages. The study material consisted of 280 individually marked Japanese quails (56♂:224♀). Birds at 5 weeks of age were randomly divided into 7 equal-sized groups with replication subgroups (4 per group, 10 birds in each replicate). Birds were kept in 0,5 m^2 cages with unlimited access to water and feed. The differentiating factor was the presence of enrichment in the birds' cages. The following groups were created: 1 – control (reared without any enrichment), 2 – nest box, 3 – scratching surface, 4 – corrugated flexible tube, 5 – limestone cube, 6 – sand bath box, and 7 – feed box with holes drilled in the cover. Bird liveability and productivity indices (laying rate, FCR, egg weight, and body weight) were recorded throughout the experiment. After 6 weeks of the experiment, 24 eggs were randomly collected from each group for qualitative analysis. The presence of an enriched environment was shown to positively influence production parameters and the quality of eggs obtained from Japanese quails compared to birds kept under standard husbandry conditions.

KEY WORDS: welfare; cage enrichment; eggs quality

INTRODUCTION

Stress is a common phenomenon in intensive animal husbandry, including poultry farms. The most common cause of stress is the inability of birds, especially those kept under intensive cage conditions, to express their natural behaviour. Legislation (Council Directive 2007/43/EC, Council Directive 1999/74/EC, Council Directive 98/58/EC) regulates appropriate housing conditions for

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most farmed species, including meat and laying birds, but in the latter case only for the species *Gallus gallus*. No standards or recommendations have been developed for the rearing environment of Japanese quail (*Coturnix japonica*), except for basic stocking density standards. At the same time. rearing and breeding of this species is growing rapidly, for the purpose of obtaining eggs (Drabik et al., 2020), meat (Genchev et al., 2008), or chicks for use in various research studies (Batkowska et al., 2018; Wlazlo et al., 2022). Japanese quails (*Coturnix japonica*) are small birds of the Phasianidae family, selected for meat and egg production. Owing to their fast growth rate, high laying rate, and short generation interval, they are also a relatively good model for poultry (Baer et al., 2015). The Japanese quail was described for the first time as a useful animal model by Padgett and Ivey (1960) and has since become a common laboratory species in studies of avian nutrition (Sigolo et al., 2019; Reda et al., 2020), reproductive biology, endocrinology (Ottinger et al., 2001), immunology, and ageing mechanisms (Holmes and Ottinger, 2003), as well as in behavioural studies (Pittet et al., 2019).

The variety of research on Japanese quails, the progressive intensity of production, and the increasing interest in the quail as a model organism suggests that behavioural research should focus on opportunities to improve quail housing conditions. Providing the bird with appropriate housing conditions allows it to feel comfortable and to express natural behaviour, which is reflected in improved welfare and increased profits for the breeder through the elimination of undesirable behaviour, reduced treatment costs and reduced mortality. It is also associated with better production results and higher product quality.

The welfare of laying birds can be improved in many ways, including enrichment of cages with elements such as perches and nests, introduced by legislation (Guesdon et al., 2006), various types of floor and/or bedding material (Blokhuis et al., 1989), equipping bird boxes with play items to stimulate environmental exploration, such as balls, bottles, bricks, brooms, brushes, buckets, containers, pet toys and plastic tubes (Bari et al., 2020), specially designed toys to distract birds and reduce potential aggression (Gvaryahu et al., 1994), and access to runs. in combination with various stocking densities (Campbell et al., 2017). These methods mainly involve additional enrichment of the birds' living space. The most important goal, apart from welfare, is to avoid adverse effects on performance traits and production economics. Similar concerns apply to Japanese quails, due to their considerable activity and cognitive curiosity, which may stimulate them to over-explore the enrichments and thus waste energy.

On the other hand, studies indicate increased stress resistance in birds kept in enriched environments. Research on Japanese quails in this context is scarce, but both our previous observations (Ramankevich et al., 2022) and reports of other authors (Miller and Mench, 2005; Nazarand Marin, 2011; Laurence et al., 2015) indicate that environmental enrichment improves birds' welfare in terms of resistance to stress or immune modulation.

We hypothesized that, despite the lack of legal requirements, additional elements in the cages of Japanese quails would be effective at improving their welfare. However, their effect on the birds' production performance should be investigated. The aim of this study was to evaluate the production parameters and egg quality of Japanese quail (*Coturnix japonica*) depending on enrichment of the birds' living environment.

MATERIALS AND METHODS

The study was approved by the Local Ethics Committee for Animal Experiments (approval no 17/2021).

The study material consisted of 280 Japanese quail (56♂ and 224♀) individually marked with wing tags. Birds at the age of 5 weeks were sexed and randomly assigned to 7 equal-sized groups with replication subgroups (4 per group, 10 birds in each replicate, 2♂ and 8♀). This experimental design made it possible to determine the effects on both male and female Japanese quails, so that the enrichments could be used in both production and breeding flocks. The experiment was begun after a 7-day period of acclimatization to the new environment. Birds were kept in 0,5 m^2 (50×100 cm) cages with unlimited access to water and feed. Standard temperature and ventilation were used, as well as a light programme (17 h light: 7 h dark). The differentiating factor was the presence of enrichment in the birds' cages. Group 1 was the control group (C), kept in standard quail cages equipped only with drinkers and feeders. The experimental groups were as follows: 2 – nest box (N – nest), 3 – scratching surface (SC – scratcher), 4 – corrugated flexible tube (T – tunnel), 5 – limestone cube (LC – limestone cube), 6 – sand bath box (SB – sandbox), and 7 – feeding box with holes drilled in the cover (F – feeder). A detailed description of the environmental enrichments can be found in a previously published study (Ramankevich, 2022).

Throughout the experiment, bird liveability and production traits, i.e. number of eggs laid. egg weight. and birds' body weight (using an electronic scale to within 0,1 g) were recorded at 7-day intervals. To determine feed intake, the residual feed was also weighed every 7 days. In the case of the group with access to a drilled feeder (F), the weight of additional feed supplied was also taken into account.

After 6 weeks of the experiment, 24 eggs were randomly collected from each group for qualitative analysis of the following traits:

1. Whole egg:
   - weight (electronic scale to within 0,01 g) (Kern, Kern &Sohn GmbH, Balingen, Germany)
   - specific gravity (measurement of egg weight both in the air and submerged in water, according to Archimedes' principle)
   - shape index (measured using a calliper as the ratio of the length of the short axis to the long axis; Limit, Alingsås, Sweden)
2. Eggshell
   - strength (force required to break the shell (N). using an Instron Mini 55 apparatus (Instron®, Norwood, MA, USA)
   - colour (measured as a % of reflected light. using a colorimeter)
   - weight (electronic scale to within 0,01 g)
   - thickness (measured at the equator, i.e. mid-height of the egg. using a micrometer screw)
   - density (Shafey, 2002)
3. Egg albumen
   - height (measured after breaking the egg on a mirror table. by contact of the EQM (Egg Quality Measurement, TSS®, York, UK) sensor with the surface of the thick albumen)
   - weight (from the difference in weight of whole egg, shell and yolk)
   - Haugh unit (Williams, 1992)

4. Egg yolk
   - colour (using a colorimeter according to Roche's 16-point scale, DSM®)
   - weight (electronic balance to within 0,01 g)
   - index (measured using a calliper, as the ratio of the yolk height to its diameter)

The SPSS 24.0 package (IBM SPSS, 2016) was used for statistical processing of the data. The normal distribution of individual variables was verified using the Shapiro-Wilk test. Groups were compared using a one-way analysis of variance according to following model:

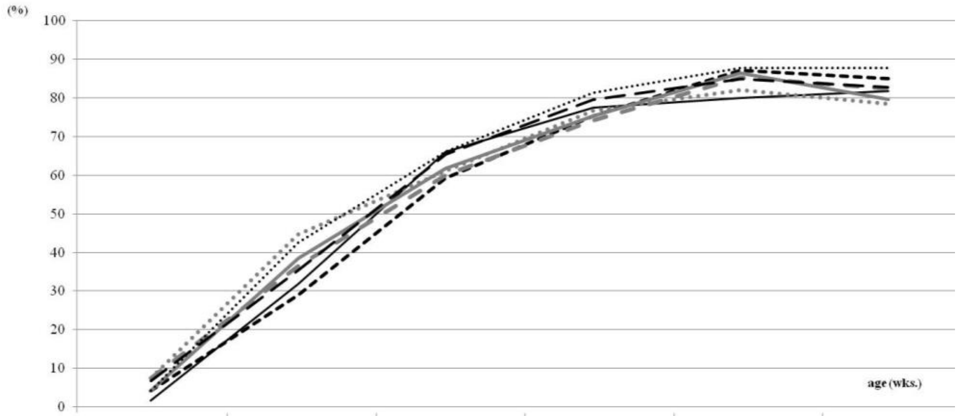
$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij},$$

where:
μ – grand mean
α_i – fixed effect of the factor (enrichment) (i = 0, 1, 2, 3, 4, 5, 6)
$\varepsilon_{ij;}$ – sampling error

Tukey's multiple comparison test was performed, Results were presented in tables as the mean and standard error of the mean (SEM).

RESULTS

Differences in laying performance between groups of Japanese quails (Fig. 1) depending on the enrichments used were found at the beginning of the laying period (weeks 1 and 2) and its end (weeks 5 and 6). In the first week, laying performance was lowest in the birds from the control group, while the highest values were obtained for groups 2 (N) and 5 (LC). In week 2, the highest values were observed for group 2 (N) and the lowest for group 3 (SC). Contrasting results were obtained at the final stage of rearing. In week 5, productivity was lowest in the birds from the control group and highest in groups 3 (SC) and 6 (SB). The highest laying performance at week 6 was recorded in group 6 (SB), and the lowest in groups 2 (N) and 4 (T).



	1	2	3	4	5	6
1 (C)	1,67a	31,79ab	66,07	77,50	80,00a	81,79ab
2 (N)	7,50b	44,64c	61,07	76,79	82,14ab	78,57a
3 (SC)	4,17ab	28,93a	59,29	75,36	87,14b	85,00ab
4 (T)	4,17ab	38,57abc	61,79	75,36	86,43ab	79,64a
5 (LC)	7,50b	36,43abc	60,00	74,29	85,36ab	82,50ab
6 (SB)	4,17ab	42,50bc	66,07	81,43	87,86b	87,86b
7 (F)	6,67ab	35,36abc	65,36	79,64	85,00ab	82,86ab

Fig. 1. Laying production of Japanese quails depending on cage enrichment, a, b – means (groups) marked with different letters differ significantly at p ≤ 0,05; groups: 1 – control (C – kept in standard quail cages equipped only with drinkers and feeders), 2 – nest box (N – nest), 3 – scratching surface (SC – scratcher), 4 – corrugated flexible tube (T – tunnel), 5 – limestone cube (LC – limestone cube), 6 – sand bath box (SB – sandbox), 7 – drilled feeding box (F – feeder)

The productivity traits of Japanese quail depending on the enrichment used were analysed throughout the rearing period. Irrespective of sex and experimental group, no significant differences were found in the liveability of birds during the rearing period. There were also no significant differences in body weight or mean feed intake – either per bird or per egg (Table 1). The total number of eggs laid showed no significant statistical differences between groups. However, the highest number of eggs laid was obtained for quails from group 6 (SB).

Table 1

Mean values of productivity traits of Japanese quails depending on cage enrichment (part 1)

Group (enrichment)			1 (C)	2 (N)	3 (SC)	4 (T)	5 (LC)	6 (SB)	7 (F)	*SEM*
Trait	Age (wks)	sex								
Liveability (%)	0-6	-	100	100	100	100	100	100	95	-
Body weight (g)	0	♂	152,43	137,86	149,75	144,88	141,86	145,38	144,38	*1,540*
		♀	155,21	160,41	158,28	160,97	158,05	156,70	156,53	*0,770*
		♂+♀	154,74	157,13	156,85	158,23	155,64	154,81	154,50	*0,730*
	1	♂	173,33	167,00	160,40	173,50	168,50	165,25	157,00	*2,750*
		♀	177,06	173,38	176,47	181,69	182,88	171,63	172,63	*1,430*
		♂+♀	176,50	172,10	172,45	180,05	180,00	170,35	169,50	*1,310*
	2	♂	168,25	150,50	161,25	159,75	158,50	155,75	162,25	*2,330*
		♀	186,75	181,63	189,69	181,69	185,50	181,50	179,06	*1,210*
		♂+♀	183,05	175,40	184,00	177,30	180,10	176,35	175,70	*1,350*
	3	♂	163,50	159,75	162,00	154,00	160,50	156,75	165,50	*2,300*
		♀	176,06	180,06	178,13	178,88	180,75	175,31	174,88	*1,390*
		♂+♀	173,55	176,00	174,90	173,90	176,70	171,60	173,00	*1,340*
	4	♂	179,50	163,50	161,80	153,00	169,75	162,50	168,40	*2,910*
		♀	169,19	178,50	177,00	174,75	180,38	170,38	178,60	*1,460*
		♂+♀	171,25	175,50	173,20	170,40	178,25	168,80	176,05	*1,340*
	5	♂	179,00	175,25	169,75	173,80	182,75	167,50	173,75	*2,980*
		♀	187,88	190,31	189,25	184,07	188,06	184,19	193,38	*1,350*
		♂+♀	186,10	187,30	185,35	181,50	187,00	180,85	189,45	*1,320*
	6	♂	194,00	183,75	192,75	176,50	187,25	181,00	187,75	*3,050*
		♀	192,31	202,75	186,25	197,25	199,19	196,13	200,69	*2,110*
		♂+♀	192,65	198,95	187,55	193,10	196,80	193,10	198,10	*1,820*
Mean daily feed intake (g/bird/ day)	1	♂+♀	28,79	28,53	29,16	29,03	29,28	28,73	29,00	*0,050*
	2	♂+♀	29,62	29,49	29,60	29,88	29,78	29,67	29,69	*0,030*
	3	♂+♀	29,97	29,75	29,96	29,98	29,98	29,98	29,88	*0,020*
	4	♂+♀	29,99	29,97	29,95	29,78	29,98	29,99	29,98	*0,010*
	5	♂+♀	29,96	29,89	29,65	29,19	29,98	29,82	29,71	*0,050*
	6	♂+♀	29,46	28,74	28,88	28,82	29,30	28,50	28,59	*0,070*

Groups: 1 – control (C – kept in standard quail cages equipped only with drinkers and feeders), 2 – nest box (N – nest), 3 – scratching surface (SC – scratcher), 4 – corrugated flexible tube (T – tunnel), 5 - limestone cube (LC – limestone cube), 6 –sand bath box (SB – sandbox), 7 – drilled feeding box (F – feeder)

Significant differences were observed for egg weights between groups (Table 2), with the highest values obtained in group 5 (LC) and the lowest in group 7 (F), but these differences were noted only in the initial stage of laying (week 1). In the final stage of rearing, the lowest values for this trait were also obtained in group 7 (feeder), while the highest were recorded in group 3 (SC). In the other groups, the values for this trait were similar. Feed conversion per egg is an indicator of production profitability (Table 2). In the second week, the highest feed intake was noted in group 3 (SC) and the lowest in groups 2 (N) and 6 (SB). In weeks 3 and 4, the groups showed no significant differences. They reappeared in the fifth week of rearing, when the highest conversion was recorded in the control group and the lowest in group 4 (T). In the final week, the feed intake required to produce one egg was also highest in the control group, followed by groups 2 (N), 4 (T) and 5 (LC), while the lowest value was obtained for birds in group 6 (SB).

Table 2

Mean values of productivity traits of Japanese quails depending on cage enrichment (part 2)

Group (enrichment)		1 (C)	2 (N)	3 (SC)	4 (T)	5 (LC)	6 (SB)	7 (F)	*SEM*
Trait	Age (wks)								
Egg weight (g)	1	8,11ab	8,96cd	8,58abc	8,16ab	9,38d	8,83bcd	7,87a	*0,170*
	2	9,65a	9,71a	9,78a	9,56a	10,05ab	10,34b	9,78a	*0,100*
	3	9,76ab	9,88b	9,78ab	9,73ab	9,57a	9,61ab	9,68ab	*0,060*
	4	10,52c	10,20bc	10,10b	10,12b	9,75a	9,93ab	10,03ab	*0,070*
	5	10,62a	10,74ab	10,97b	10,66a	10,53a	10,71ab	10,60a	*0,050*
	6	10,85ab	10,96ab	11,17b	11,02ab	10,83ab	10,92ab	10,74a	*0,070*
FCR (g/egg)	1	-	-	-	-	-	-	-	-
	2	108,50ab	81,60a	122,35b	87,62ab	84,42ab	74,64a	84,01ab	*3,730*
	3	45,44	49,62	51,38	50,67	50,42	45,61	47,84	*0,730*
	4	38,86	39,34	40,78	39,96	40,68	36,89	38,02	*0,410*
	5	35,42c	34,11bc	31,87ab	31,47a	33,01ab	31,81ab	32,95ab	*0,240*
	6	36,01b	36,61b	33,92ab	36,10b	35,60b	32,21a	34,65ab	*0,310*
Total number of eggs	1-6	946	970	945	962	957	1029	983	*5,150*

a-d – means (groups) marked with different letters differ significantly at p ≤ 0,05; SEM – standard error of mean; groups: 1 – control (C – kept in standard quail cages equipped only with drinkers and feeders), 2 – nest box (N – nest), 3 – scratching surface (SC – scratcher), 4 – corrugated flexible tube (T – tunnel), 5 - limestone cube (LC – limestone cube), 6 – sand bath box (SB – sandbox), 7 – drilled feeding box (F – feeder); FCR – feed conversion ratio

Table 3 shows the quality characteristics of Japanese quail eggs depending on the cage enrichment used. Eggs from group 4 (T) had the lowest shape index value. indicating the most elongated shape, while groups 2 (N), 3 (SC), and 7 (F) produced the roundest eggs (with the highest shape indices). Total egg weight was highest in the group whose cages were equipped with a tunnel (4) and the group with access to a sandbox (6), while the lowest values were found in groups 5 (LC) and 7 (F). Regarding the proportions of individual egg elements. the share of shell in the egg weight did not differ significantly between the experimental groups. However, the proportion of albumen was lowest in eggs from the control group and highest in group 6 (SB). The reverse pattern was shown for the proportion of yolk in the egg weight. which was lowest in the control group and highest in group 4 (tunnel). The specific gravity was highest for eggs from birds with access to a nesting space (group 2) and lowest in groups 4 (tunnel), 5 (limestone cube) and 6 (sandbox).

Table 3

Quality traits of Japanese quail eggs depending on cage enrichment

Group (enrichment) Trait		1 (C)	2 (N)	3 (SC)	4 (T)	5 (LC)	6 (SB)	7 (F)	*SEM*
Egg shape index		0,791b	0,794b	0,796b	0,774a	0,789ab	0,793b	0,793b	*0,001*
Egg weight (g)		11,62ab	11,48ab	11,50ab	11,84b	11,27a	11,67b	11,23a	*0,040*
Proportion (%)	shell	14,52	14,04	14,63	14,33	14,28	13,97	14,89	*0,120*
	albumen	51,51a	54,03ab	54,02ab	52,83ab	54,05ab	55,28b	53,89ab	*0,280*
	yolk	28,97a	31,93bc	31,35bc	32,84c	31,67bc	30,75ab	31,22bc	*0,190*
Specific gravity (g/cm^3)		1,071ab	1,074b	1,068abc	1,065a	1,064a	1,066a	1,067ab	*0,000*
Albumen	weight (g)	6,03a	6,21ab	6,21ab	6,25ab	6,09ab	6,45b	6,07ab	*0,040*
	height (mm)	4,56b	4,47ab	4,41ab	4,57b	4,12a	4,72b	4,52ab	*0,040*
	Haugh unit	89,74b	89,22ab	88,94ab	89,52ab	87,30a	90,56b	89,69ab	*0,220*
	pH	9,24ab	9,26ab	9,27ab	9,28b	9,28b	9,22a	9,22a	*0,000*
Yolk	weight (g)	3,39a	3,66bc	3,61ab	3,89c	3,58ab	3,59ab	3,50ab	*0,020*
	colour (pts)	4,40a	5,00c	4,55ab	4,70abc	4,75abc	5,00c	4,80bc	*0,040*
	index	0,417b	0,409ab	0,406ab	0,402ab	0,396a	0,420b	0,406ab	*0,002*
	pH	6,12bc	6,07ab	6,14bc	6,19c	6,09bc	5,96a	6,08b	*0,010*
Eggshell	strength (N)	10,36a	12,26ab	13,55b	10,28a	12,97ab	14,76b	14,26b	*0,280*
	colour (%)	30,25ab	31,60b	31,35b	31,60b	29,40ab	29,65ab	25,90a	*0,420*
	weight (g)	1,70	1,61	1,68	1,70	1,61	1,63	1,67	*0,010*
	thickness (mm)	0,177a	0,184ab	0,197ab	0,201b	0,197ab	0,195ab	0,195ab	*0,001*
	density (g/cm^3)	3,93b	3,62ab	3,55a	3,42a	3,46a	3,42a	3,63ab	*0,030*

a-c – means (groups) marked with different letters differ significantly at $p \leq 0,0$; SEM – standard error of mean; groups: 1 – control (C – kept in standard quail cages equipped only with drinkers and feeders), 2 – nest box (N – nest), 3 – scratching surface (SC – scratcher), 4 – corrugated flexible tube (T - tunnel), 5 – limestone cube (LC – limestone cube), 6 – sand bath box (SB – sandbox), 7 – drilled feeding box (F – feeder)

Eggs from group 6 (SB) had the highest albumen weight. while the lowest value was recorded in the control group. The albumen height was lowest in group 5 (limestone cube), and significantly the highest in groups 1 (control), 4 (T) and 6 (SB). Similar relationships between groups were observed in the case of Haugh units. The albumen pH value in fresh eggs was lowest in groups 6 and 7 (sandbox and feeder) and significantly the highest in groups 4 and 5 (tunnel and limestone cube). Analysis of egg yolk quality traits showed that yolk weight was significantly the lowest in the control group and the highest in group 4 (T). The yolk colour was most intensive in eggs obtained from quail in groups 2 (N) and 6 (SB) and least intensive in the control group. The lowest yolk shape index was found in eggs from group 5 (LC), while the highest values, indicating the roundest shape, were recorded in the control group and the group with access to a sand bath (group 6, SB). The yolk pH was also the lowest in this group. Evaluation of eggshell quality revealed that the strength of eggshells from the control and group 4 (tunnel) was considerably lower than in groups 3 (SC), 6 (SB) and 7 (F). Shell weight did not differ significantly depending on the enrichment used in the quail cages. The thickest shell was observed in eggs from birds in group 4 (T), and the thinnest in eggs from the control group.

DISCUSSION

One of the basic elements of poultry production determining flock management is the birds' productive performance. In our study, no significant differences in body weight were observed between groups. The results do not differ from those described by Zelenka et al. (1984). Data presented by El-Tarabany (2016) for body weight in groups of Japanese quail subjected to heat stress are similar to our findings. In that study the results for the control group were significantly higher, which may indicate the role of stress in determining Japanese quail body weight.

The results of our study also showed no significant differences in daily feed intake depending on the experimental group, and the data are consistent with those presented by Pieroni et al. (2020) for a control group fed standard compound feed. Sahin and Kucuk (2003) found that daily feed intake decreased with heat stress. The results obtained by the authors for the control group are similar to those obtained in our study, which may indirectly suggest a low stress level in the birds included in the experiment.

Egg weight .was observed to increase with the duration of the experiment. This relationship has previously been described for hens (Zita et al., 2009) as well as for Japanese quails (Nowaczewski et al., 2010). It should be noted that the results of our study are significantly higher than those presented by other authors (Nagarajan et al., 1991) for birds of similar ages. In general. researchers indicate that not only age but also stocking density (Nagarajan et al., 1991), environmental conditions, diet (Nowaczewski et al., 2010) and heat stress (Alagawany et al., 2017) significantly affect the weight of eggs. In our study, however, the birds were kept in identical environmental conditions and fed the same balanced diet, so the differences observed are directly due to the enrichment of the birds' living environment.

The quality of Japanese quail eggs, as in other poultry species. is influenced by a number of factors associated with flock age (Nowaczewski et al., 2010), genetic background (Hrnčár et al.,2014), diet, and flock management system. In the case of Japanese quails. shell colour also plays an important role in determining egg quality. Eggs with standard spotting usually weigh more and have a higher proportion of albumen than those with a plain shell (Taha. 2011; Drabik et al., 2020). In our study all eggs were standard coloured, so the enrichment used was the only diversifying factor. The differences observed, both in egg weight and the proportions of its individual elements, are probably linked to the age of sexual maturity of the birds, as these characteristics change with the age of the flock (Nowaczewski et al., 2010). However, it cannot be conclusively determined whether the earlier start of laying in some experimental groups was linked to the enrichment or solely to individual variability.

Interesting observations can be made concerning eggshell quality characteristics. The fact that the best eggshell strength was obtained in the group of birds with access to a sandbox was probably due to intake of micro-and macroelements from the sand. Many studies confirm that the addition of minerals to the diet of birds has a positive effect on eggshell quality (Um and Paik, 1999; Stefanello et al., 2014). Interestingly, similar variation was not observed in the group of birds with access to a limestone cube. Such cubes are commonly used in cage rearing of ornamental birds, mainly to meet their mineral requirements. Unfortunately, these observations were not reflected in our study, probably because the birds perceived the limestone as foreign objects whose colour, shape and placement on the cage wall were unattractive to them.

CONCLUSIONS

Enrichments, which allow the quails to exhibit their natural behaviour. do not adversely affect the number of eggs obtained, the body weight of the birds. or their liveability. This indicates that they do not cause the birds to overexploit their environment, which could result in energy losses.

Enrichment in the form of a sandbox, introduced to provide sand baths for the birds, is at the same time a source of mineral elements and has a positive influence on eggshell quality, including its strength.

Enrichment of the living environment of Japanese quail (*Coturnix japonica*) has a positive effect on production parameters and egg quality compared to birds kept under standard conditions.

REFERENCES

1. Alagawany M., Farag M. R., Abd El-Hack M. E., Patra A. (2017). Heat Stress: Effects on Productive and Reproductive Performance of Quail. World's Poultry Science Journal, 73: 747-756, doi: 10.1017/S0043933917000782
2. Baer J., Lansford R., Cheng K. (2015). Chapter 22 - Japanese Quail as a Laboratory Animal Model. In: Laboratory Animal Medicine (Third Edition); Fox, J.G., Anderson. L.C., Otto. G.M., Pritchett-Corning. K.R., Whary. M.T., (eds.), American College of Laboratory Animal Medicine; Academic Press: Boston, pp. 1087-1108 Achaya K.T.
3. Bari M. S., Cohen-Barnhouse A. M., Campbell D. L. M. (2020). Early Rearing Enrichments Influenced Nest Use and Egg Quality in Free-Range Laying Hens. Animal, 14: 1249-1257, doi: 10.1017/S1751731119003094
4. Batkowska J., Al-Shammari K. I. A., Wlazlo L., Nowakowicz-Debek B., Gryzinska M. (2018). Evaluation of Propolis Extract as a Disinfectant of Japanese Quail (Coturnix coturnix japonica) Hatching Eggs. Poultry Science, 97: 2372-2377, doi: 10.3382/ps/pey102
5. Blokhuis H. J., Van Der Haar J. W. (1989). Effects of Floor Type during Rearing and of Beak Trimming on Ground Pecking and Feather Pecking in Laying Hens. Applied Animal Behaviour Science, 22: 359-369, doi: 10.1016/0168-1591(89)90030-0
6. Campbell D. L. M., Lee C., Hinch G. N., Roberts J. R. (2017). Egg Production and Egg Quality in Free-Range Laying Hens Housed at Different Outdoor Stocking Densities. Poultry Science, 96: 3128-3137, doi: 10.3382/ps/pex107
7. Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. Official Journal L 203, 03.08.1999: 53-57
8. Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production. Official Journal L 182, 12.07.2007: 19-28
9. Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. Official Journal L 221, 08.08.1998: 23-27

10. Drabik K., Batkowska J., Vasiukov K., Pluta A. (2020). The Impact of Eggshell Colour on the Quality of Table and Hatching Eggs Derived from Japanese Quail. Animals, 10: 264, doi: 10.3390/ani10020264
11. El-Tarabany M. S. (2016). Impact of Temperature-Humidity Index on Egg-Laying Characteristics and Related Stress and Immunity Parameters of Japanese Quails. Int J Biometeorol, 60: 957-964, doi: 10.1007/s00484-015-1088-5
12. Genchev A., Mihaylova G., Ribarski S., Pavlov A., Kabakchiev M. (2008). Meat quality and composition in japanese quails. Trakia Journal of Sciences**,** 6(4): 72-82
13. Guesdon V., Ahmed A. M. H., Mallet S., Faure J. M., Nys Y. (2006). Effects of Beak Trimming and Cage Design on Laying Hen Performance and Egg Quality. British Poultry Science, 47: 1-12, doi: 10.1080/00071660500468124
14. Gvaryahu G., Ararat E., Asaf E., Lev M., Weller J. I., Robinzon B., Snapir N. (1994). An Enrichment Object That Reduces Aggressiveness and Mortality in Caged Laying Hens. Physiology & Behavior, 55: 313-316, doi: 10.1016/0031-9384(94)90139-2
15. Holmes D. J., Ottinger M. A. (2003). Birds as Long-Lived Animal Models for the Study of Aging. Experimental Gerontology, 38: 1365-1375, doi: 10.1016/j.exger.2003.10.018
16. Hrnčár C., Hanusova E., Hanus A. Bujko J. (2014). Effect of Genotype on Egg Quality Characteristics of Japanese Quail (Coturnix japonica). Slovak Journal of Animal Science, 47: 6-11
17. IBM SPSS Statistics for Windows Armonk (2016). Version 24.0; IBM Corp.: Armonk, NY, USA, 2016.
18. Laurence A., Houdelier C., Calandreau L., Arnould C., Favreau-Peigné A., Leterrier C., Boissy A., Lumineau S. (2015). Environmental Enrichment Reduces Behavioural Alterations Induced by Chronic Stress in Japanese Quail. Animal, 9: 331-338, doi: 10.1017/S1751731114002523
19. Miller K. A., Mench J. A. (2005). The Differential Effects of Four Types of Environmental Enrichment on the Activity Budgets, Fearfulness, and Social Proximity Preference of Japanese Quail. Applied Animal Behaviour Science, 95: 169-187, doi: 10.1016/j.applanim.2005.04.012
20. Nagarajan S., Narahari D., Jayaprasad I. A., Thyagarajan D. (1991). Influence of Stocking Density and Layer Age on Production Traits and Egg Quality in Japanese Quail. British Poultry Science, 32: 243-248, doi: 10.1080/00071669108417347
21. Nazar F. N., Marin R. H. (2011). Chronic Stress and Environmental Enrichment as Opposite Factors Affecting the Immune Response in Japanese Quail (Coturnix coturnix japonica). Stress, 14: 166-173, doi: 10.3109/10253890.2010.523093
22. Nowaczewski S., Kontecka H., Rosiński A., Koberling S., Koronowski P. (2010). Egg Quality of Japanese Quail Depends on Layer Age and Storage Time. Folia Biologica, 58: 201-207, doi: 10.3409/fb58_3-4.201-207
23. Ottinger M. A., Abdelnabi M. A., Henry P., McGary S., Thompson N., Wu J. M (2001). Neuroendocrine and Behavioral Implications of Endocrine Disrupting Chemicals in Quail. Hormones and Behavior, 40: 234-247, doi: 10.1006/hbeh.2001.1695
24. Padgett C. S., Ivey W. D. (1960). The normal embryology of the coturnix quail. The Anatomical Record, 137(1): 1-11, doi: 10.1002/ar.1091370102
25. Pieroni C. A., Oliveira. M. C. D., Santos. W. L. R. D., Mascarenhas. L. B., Oliveira. M. A. D. (2020). Effect of green propolis on the productivity. nutrient utilisation. and intestinal morphology of Japanese laying quail. Revista Brasileira de Zootecnia, 49, doi: 10.37496/rbz4920190198

26. Pittet F., Tyson C., Herrington J. A., Houdelier C., Lumineau S. (2019). Postnatal Care Generates Phenotypic Behavioural Correlations in the Japanese Quail. Behavioural Ecology and Sociobiology, 73: 120, doi: 10.1007/s00265-019-2735-3
27. Ramankevich A., Wengerska K., Rokicka K., Drabik K., Kasperek K., Ziemiańska A., Batkowska J. (2022). Environmental Enrichment as Part of the Improvement of the Welfare of Japanese Quails. Animals, 12: 1963, doi: 10.3390/ani12151963
28. Reda F.M., El-Kholy M. S., Abd El-Hack M. E., Taha A. E., Othman S. I., Allam A. A., Alagawany M. (2020). Does the Use of Different Oil Sources in Quail Diets Impact Their Productive and Reproductive Performance, Egg Quality, and Blood Constituents? Poultry Science, 99: 3511-3518, doi: 10.1016/j.psj.2020.03.054
29. Sahin K., Kucuk O. (2003). Zinc Supplementation Alleviates Heat Stress in Laying Japanese Quail. The Journal of Nutrition, 133: 2808-2811, doi: 10.1093/jn/133.9.2808
30. Shafey T. M. (2002). Effects of Egg Size and Eggshell Conductance on Hatchability Traits of Meat and Layer Breeder Flocks. Asian-Australasian Journal of Animal Sciences, 15: 1-6, doi: 10.5713/ajas.2002.1
31. Sigolo S., Khazaei R., Seidavi A., Ayasan T., Gallo A., Prandini A. (2019). Effects of Supra-Nutritional Levels of Vitamin E and Vitamin C on Growth Performance and Blood Parameters of Japanese Quails. Italian Journal of Animal Science, 18: 140-146, doi: 10.1080/1828051X.2018.1500496
32. Stefanello C., Santos T. C., Murakami A. E., Martins E. N., Carneiro T.C. (2014). Productive Performanc, Eggshell Quality, and Eggshell Ultrastructure of Laying Hens Fed Diets Supplemented with Organic Trace Minerals. Poultry Science, 93: 104-113, doi: 10.3382/ps.2013-03190
33. Taha A. E. (2011). Analyzing of quail eggs hatchability, quality, embryonic mortality and malpositions in relation to their shell colors. Journal of Animal and Feed Sciences, 1: 267-273
34. Um J., Paik I. (1999). Effects of Microbial Phytase Supplementation on Egg Production, Eggshell Quality, and Mineral Retention of Laying Hens Fed Different Levels of Phosphorus. Poultry Science, 78: 75-79, doi: 10.1093/ps/78.1.75
35. Williams K. C. (1992). Some Factors Affecting Albumen Quality with Particular Reference to Haugh Unit Score. World's Poultry Science Journal, 48: 5-16, doi: 10.1079/WPS19920002
36. Wlazlo L., Drabik K., Al-Shammari K. I. A., Batkowska J., Nowakowicz-Debek B., Gryzińska M. (2022). Use of Reactive Oxygen Species (Ozone, Hydrogen Peroxide) for Disinfection of Hatching Eggs. Poultry Science, 99: 2478-2484, doi: 10.1016/j.psj.2019.12.039
37. Zelenka D. J., Cherry J. A., Nir I., Siegel P. B. (1984). Body Weight and Composition of Japanese Quail (Coturnix coturnix japonica) at Sexual Maturity. Growth, 48: 16-28
38. Zita L., Tůmová E., Štolc L. (2009). Effects of Genotype. Age and Their Interaction on Egg Quality in Brown-Egg Laying Hens. Acta Veterinaria Brno, 78: 85-91, doi: 10.2754/avb200978010085

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