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Original Contribution

POTENTIAL FOR USE OF INTERRUPTED HEATING REGIMENS IN JAPANESE QUAIL REARING

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ABSTRACT

The continuously increased price of energy sources and the serious ecological problems on a worldwide scale entail the development, and practical implementation of energy-saving poultry rearing technologies. One of possible alternatives with this regard is the utilization of interrupted heating regimens in poultry rearing. The purpose of the present study was to confirm the potential of interrupted heating regimens during day and night in Japanese quail rearing systems. The experiment was performed in the experimental vivarium of the Poultry breeding Section at the Faculty of Agriculture, Trakia University, in November-December 2008 with Japanese quails *(Coturnix Japonica)*, from the meat-type Pharaoh breed. For heating were used 250 W infrared quartz lamps. The heating regimen consisted of constant temperature with gradual decrease according to the age (control group) and alternation of heating and cooling periods with increased duration of cooling periods with age for experimental groups. The live body weight, the vitality, the feed and water consumptions were monitored. At the end of the experiment, a slaughter analysis of the meat production was performed. The experiment showed that the application of interrupted heating regimens during the first three weeks of life in Japanese quails, did not influence the vitality or the live body weight of birds at the age of 21 and 35 days. The tested factor did not influence the quantitative traits of produced meat. In the period between the 1^{st} and 21^{st} days of age, Japanese quails that were reared under interrupted heating regimens, have consumed by 2.3-5.4% less feed and by 3.4-5.1% less water on the average, whereas the feed conversion ratio was by 3.8-7.6% more efficient compared to quails reared at constant temperatures. Consequently to the application of interrupted heating regimens, the energy costs for heating of quails were reduced by 33.6-42% that, together with the lower feed expenditure and its better conversion, showed a potential for reduction of the total costs related to Japanese quail meat production by 28.7-36.5%.

Key words: Japanese quails, heating regimen, productivity, efficiency of meat production

INTRODUCTION

An important potential for increasing the efficacy of poultry husbandry is the reasonable solution of issues related to heating practices during the first three weeks of the life of birds. Similarly to mammals, birds are homeothermic animals. Their thermoregulation is controlled by the central nervous system and according to the occurring physiological events, it is either physical or chemical. In the opinion of most authors, as early as at hatching, birds possess mechanisms for chemical thermoregulation, but experience problems with the maintenance of constant body temperature during the first days of life due to the imperfect physical thermoregulation (1). In the opinion of Nichelmann and Tzschentke, this stage of unstable thermoregulation continues up to the age of 10 days (2). By its end, by virtue of maturation of thermoregulatory mechanisms, birds are more or less able to maintain a relatively constant body temperature. According to data of Selyanskiy, up to the age of 20 days, the body temperature in birds remains by about 0.5-1 ^{o}C lower compared to adult birds (3). In the opinion of the author, this is related to the still inadequate thermoregulation mechanisms. Therefore, young birds are dependent on external heat sources.

A main priority in the modern industrial poultry husbandry systems is the maintenance of a relatively stable microclimate with gradual

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decrease of ambient temperature during the first three weeks of life. It is acknowledged that these principles are essential for the welfare of birds but they are not in agreement with the real environmental conditions of their evolution. In a review on the literature about quails reared under natural conditions, Afanasiev et al. state that during the first 24 hours after hatching, the quails are constantly under the wing of the quail hen and are heated by maternal body (4). During this 24-hour period, newly hatched chicks are entirely counting on the egg yolk reserve, which according to Mihaylov et al. amount to about 10.36% of the pure hatching weight (5). During the next 24 hours, they go out for a while for several feedings. After the third 24-hour period, exogenous nutrients become essential for chick nutrition, because of the rapid depletion of yolk reserves (over 2 times for the first 24 hours and about 3 times for the next 24 hours) (5). During the third 24-hour period, the alternation of periods of maternal body heating and cooling during feeding becomes more frequent with increased feeding periods' duration with every passing day. Taking into consideration the described biological rhythm, that predetermines the behavior of quails in their first days of life (6). As a result of these experiments, the author recommends the alternation of 60-minute periods of heating with 30-minute periods of cooling for 16.5 h out of 24 hours between 3 and 21 days of age. In the author's opinion, this heating regimen improved the blood parameters of quails, increased the survival rate by almost 8% and reduced by 20.7% the energy costs for heating of quails.

The continuously increased price of energy sources and the serious ecological problems on a worldwide scale entail the development and practical implementation of energy-saving poultry rearing technologies. The promising results of Afanasiev (6) from the utilization of interrupted heating regimens in Japanese quail rearing during the light part of the day motivate further investigations. The purpose of the present study was to confirm the potential of interrupted heating regimens during the day and the night in Japanese quail rearing systems.

MATERIAL AND METHODS

The experiment was performed in the experimental vivarium of the Poultry breeding Section at the Faculty of Agriculture, Trakia University, in November-December 2008 with Japanese quails *(Coturnix Japonica)*, from the meat-type Pharaoh breed. At hatching, 298 quails were marked, individually weighed and divided into three groups with equal average weight.

Housing. The quails from the different groups were housed in cages as follows: group 1 (control) – 100 birds; group 2 (experimental) – 99 birds, group 3 (experimental) – 99 birds. The batteries were two-floor, each floor consisting of two cages with dimensions 800x1000x600 mm. Infrared quartz lamps of 250 W were used for heating. From the age of 1 to 10 days, the quails from each group were placed in separate cages at the lower floor of batteries. On lower floors, one lamp heated an area of 0.8 m^2 and thus permitted the maintenance of a higher ambient temperature in cells. From the age of 1 to 10 days, each quail had at its disposal an area of 81 cm^2. The real free area during this age period (without the area occupied by the feeding and watering troughs) was 61.5 cm^2. After being weighed at the age of 10 days, the quails of each group were divided into two parts and moved into the pens of the upper floors of the batteries where one lamp heated an area of 1.6 m^2. From the 10th to the 21st day of age, each bird had 163 cm^2 total or 124 cm^2 real area of pen's floor. After the weighing at the age of 21 days, the birds from each group were divided according to their gender and then a gender separate rearing was practiced. From the age of 21 days to the end of the experiment, the birds of each group disposed of 330 cm^2 total or 250 cm^2 real area from the pen's floor.

Experimental design

Age, days	Temperature of the contact thermometer	Group 1 (control)	Group 2 (experimental)	Group 3 (experimental)
1	33	Continuous heating with quartz lamps		
2-3	32	Continuous heating with quartz lamps		
4-7	31	Turning the heating either on or off is connected via the contact thermometer	15' off : 30'on	15' off : 30' on
8-10	30		15' off : 30' on	15' off : 15' on
11-14	28		30' off : 60' on	30' off : 30' on
15-17	26		45' off : 60' on	45' off : 30' on
18-21	24		60' off : 60' on	60' off : 30' on
22-28	24	Maintenance of a background temperature in the premise, connected to the settings of the contact thermometer		
After the 28th day of age	22			

Heating. To verify the possibility for utilization of energy saving heating regimens in quail rearing during the first 3 weeks of life, the following heating regimen was used.

To verify the equivalence of planned temperature regimen to the real one, one minimum-maximum thermometer was placed in each cage with birds and in the premise. Separately, the air temperature outside the premise was monitored with a thermometer. The minimum and maximum temperatures in each cage with birds and the premise were recorded on a daily basis. The records were taken in the morning between 8.00–8.30 AM, in the course of the first entrance in the premise where birds were kept. The outside temperature was recorded in the morning between 8.00–8.30 AM and in the afternoon at 2 PM. The minimum-maximum thermometers were reset at 2 PM (one hour after the consumption of water and food has finished).

For monitoring of the real consumption of electric energy, the power supply to each battery (group) was connected to a separate watt-hour meter, whose readings were registered at each control weighing of quails.

Control weighings were performed on Chirana 02 automated scales with a precision of 0.1 g at hatching, and by the age of 3, 7, 10, 14, 17, 21, 28 and 35 days.

The death rates were recorded on a daily basis, in the morning, simultaneously with air temperature monitoring.

Feeding and drinking. During the experimental period, the quails were fed forages with the following composition:

- From 1 to 10 days of age: metabolizable energy – 10.7 MJ/kg, crude protein – 24%, Ca – 1.2%, utilizable P – 0.5%, lysine – 1.3%, methionine+cysteine – 0.88%;
- From 11 to 21 days of age: metabolizable energy – 10.8 MJ/kg, crude protein – 22%, Ca – 1.1%, utilizable P – 0.45%, lysine – 1.25%, methionine+cysteine – 0.84%;
- After the age of 22 days: metabolizable energy – 11.6 MJ/kg, crude protein – 18%, Ca – 1.0%, utilizable P – 0.4%, lysine – 1.0%, methionine+cysteine – 0.70%;

The consumption of feed and water was controlled on a daily basis between 12 AM and 1 PM. through weighing of feed placed for each group and the remnants from the previous day using a technical scale with a precision of 5 g. For obtaining more correct results, the feed in the through and that scattered on the cage floor were gathered, winnowed and then weighed. The water in drinking troughs was measured with a graduated cylinder with a precision of 5 ml.

With regard to the adequate monitoring of consumed water, a drinking through with water was placed in the adjacent empty cage (blind sample) to measure the amount of evaporated water. This volume was added to the volume of water that remained from the previous day and thus, the real water consumption was obtained.

Slaughter analysis. At the age of 35 days, the quails were slaughtered. Six birds of each gender and from each group, of an average live body weight were selected and a slaughter analysis was performed. The slaughtering and the analysis were done according to the procedures described by Genchev and Mihaylov for slaughter analysis in experiments with Japanese quails (7).

The data obtained in the experiment were statistically processed by routine statistical procedures by means of *MS Excel 2003* software. The effect of the tested factor on the growth of quails was verified by dispersion analysis (8).

RESULTS

Depending on the regimen of turning on and off of heating in batteries, the variations of minimum and maximum temperatures were different **(Table 1)**. In the period of 4−7 days of age when both experimental groups were under an identical heating regimen, there were some difference in the maximum and minimum temperatures in batteries where groups 2 and 3 were housed. This difference was due to the fact that the battery with quails from group 3 was nearer to the door of the premise. This difference had no negative effect on quails, as confirmed by the vitality of birds **(Table 2)**.

In the period between the 4th and 7th days of age, quails from experimental groups consumed less feed and water compared to control quails. The birds from group 2 consumed on the average by 7% less feed and by 10.6% less water. In group 3, these differences were by 5% and 9.3% respectively **(Table 3)**.

In the period between the 4th and 7th days of age, the feed conversion ratios of birds from experimental groups were higher compared to controls and this has somewhat compensated for the slowing of growth rate of experimental quails **(Table 4)**.

Table 1. *Variations of the temperature in cages with birds, min – max^{o}C*

Period of age, days	In premise	In cages		
		1	2	3
0-3	26,6-29,0	32,0-32,5	31,7-32,3	31,8-32,4
4-7	23,9-26,5	29,1-30,6	27,9-30,4	25,8-29,8
8-10	25,3-27,7	30,0-30,5	27,0-28,7	23,7-27,8
11-14	24,8-28,0	28,8-29,6	25,9-28,8	23,1-27,6
15-17	23,1-25,0	28,0-28,7	26,8-28,5	24,2-27,3
18-21	21,2-23,0	24,8-27,3	23,2-26,0	20,8-25,7
22-28	21,5-24,0	21,1-24,2	19,5-23,3	20,3-23,2
29-35	21,0-23,2	20,5-22,7	20,0-22,0	19,6-21,5

Table 2. *Liveability through the control period, %*

Period of age, days	Groups					
	1		2		3	
	n	%	n	%	n	%
1	100		99		99	
1-3	100	100	98	99	99	100
4-7	100	100	96	98	98	99
8-10	100	100	96	100	98	100
11-14	99	99	96	100	97	99
15-17	99	100	96	100	97	100
18-21	99	100	96	100	97	100
1-21	99	99	96	97	97	98

Table 3. *Average daily consumption of feed (g) and water (ml)*

Period of age, days	Groups					
	1		2		3	
	Feed	Water	Feed	Water	Feed	Water
1-3	3,47	10,24	3,40	10,09	3,49	10,22
4-7	7,84	23,18	7,33	20,96	7,45	21,21
8-10	13,23	31,73	13,11	30,03	13,01	32,28
11-14	16,28	30,92	16,21	30,29	15,49	29,44
15-17	19,20	34,68	18,37	33,45	16,77	30,51
18-21	21,70	38,82	21,39	39,26	21,06	37,77
1-21	13,73	28,49	13,42	27,56	13,03	27,12

Table 4. *Average daily gain (g) and feed conversion ratio(kg/kg)*

Period of age, days	Groups					
	1		2		3	
	Daily gain	FCR	Daily gain	FCR	Daily gain	FCR
4-7	4.00±0.12	1.97	3.84±0.10	1.94	3.90±0.11	1.91
8-10	5.77±0.12a	2.32	5.49±0.12	2.39	5.42±0.11a	2.39
11-14	5.83±0.13	2.86	5.97±0.13	2.72	5.95±0.14	2.68
15-17	6.38±0.12ab	3.01	5.99±0.12a	3.06	5.93±0.14b	2.86
18-21	6.59±0.14	4.03	6.80±0.13	3.74	6.77±0.18	3.21
4-21	5.62±0.11	2.70	5.62±0.11	2.64	5.70±0.09	2.51

Note: a,b; Values within rows with common letters differ significantly $P<0.05$

In group 2, the average daily weight gain was lower by 4.2% compared tot he control group and in group 3 – by 2.6% lower but the differences were not statistically significant. The facts reported so far had not a significant impact on the average live body weight of quails at the age of 7 days **(Table 5)**.

The reduction of fixed temperature of the contact thermometer between days 8 and 10 of life combined with the twofold reduction of the heating period of group 3 resulted in higher deviation between maximum and minimum temperatures compared to respective values for controls. The outcome of the combination of lower feed consumption (by 1.7%) and the less efficient conversion (by 3%) exhibited by quails from group 3 as compared to controls was a statistically significant difference in the daily weight gain of birds (P<0.05). The live body weight by the 10th day of age was the lowest in group 3, but the difference of 3.8% was not statistically significant.

Table 5. *Body weigh, g*

Age, days	Groups					
	1		2		3	
1	9,23±0,06		9,25±0,06		9,21±0,06	
3	16,05±0,17		16,12±0,15		15,94±0,16	
7	32,08±0,56		31,58±0,50		31,39±0,54	
10	49,39±0,79		48,05±0,73		47,56±0,79	
14	72,73±1,18		71,92±1,15		71,33±1,23	
17	91,88±1,40		89,90±1,35		88,93±1,56	
21	118.48±1.71		118.70±1.54		118.70±1.69	
	♂, n=50	♀, n=49	♂, n=48	♀, n=48	♂, n=49	♀, n=48
21	120.4±2.2	116.3±2.7	117.4±2.2	120.0±2.2	116.5±2.3	121.8±2.4
28	159.6±2.4	156.5±3.0	155.6±2.4	163.7±2.9	154.5±2.5	164.3±2.72
35	188.2±3.2	198.0±3.4	184.3±3.0	201.7±3.6	184.8±3.1	200.9±3.6

The slowing of quail growth rate observed up to the 10th day in experimental groups was gradually compensated in the period between 11 and 14 days of age. Within this period, the daily weight gain in experimental groups was higher compared to the control group − by 2.4% and 2.1% for groups 2 and 3, respectively. This results was influenced also by the more efficient feed conversion by experimental birds − by 5.1-6.7%. Consequently, by the age of 14 days, the difference between the live body weight of quails from the control and experimental groups was reduced to 1.1-2%.

The considerable reduction of heating time for quails from group 3 during the period between the 15-17 days of age had a negative effect on the consumption of feed. The quails from group 3 consumed by 14.5% less feed vs controls and by 9.5% less vs quails from group 2. The feed conversion rate during this period was however the most efficient in group 3. By that time, the daily weight gain in experimental groups was statistically significantly lower (P<0.05) compared to controls. As a result, the difference between average live body weight between control and experimental groups augmented once again to 2.2-3.3%, but was not statistically significant.

Between the 18th and the 21st day of age, experimental quails exhibited a higher daily weight gain by 2.7−3.2% vs controls. Similarly to the preceding age periods, the feed conversion was better in experimental groups and the difference was particularly marked between groups 1 and 3, reaching 25.5%. As a result, the recorded lower live body weight from the period between 15-17 days of age was compensated and the control weighing by the 21st day showed insignificant differences.

The vitality of birds was very high for the entire period, critical with regard to heating, and there was no tendency about influence of the studied factor. During this period, experimental quails consumed by 2.3−5.4% less feed and by 3.4-5.1% less water. The average results for the period showed that feed conversion in experimental groups was by 3.8-7.6% more efficient compared to that of control quails. The negative events described in the earlier periods, especially for experimental group 3, were later compensated and the average results for the period from day

1 to day 21 of age in this group were the most favorable.

For the experimental period in general, consequently to the application of interrupted heating regimens, the energy savings amounted to 33.6%−42% **(Table 6)**. The thorough analysis of costs in this experimental design showed that when infrared quartz lamps were sued for heating, heating costs amounted to 21% of the total rearing costs (group 1). The application of the experimental heating regimens resulted in reduction of the relative share of heating costs up to 15% (group 2) and 13.4% (group 3), i. e. a total costs reduction of 28.7% (group 2) and 36.5% (group 3).

Table 6. *Structure of spent electricity, % in comparison 1 group*

Period of age, days	Groups		
	1	2	3
4-7	100	-33,7	-33,7
8-10	100	-29,7	-47,4
11-14	100	-10,3	-16,7
15-17	100	-48,3	-56,7
18-21	100	-46,7	-59,3
Total	100	-33,6	-42,0

The slaughter analysis results **(Table 7)** showed that the tested heating regimens did not influence the quantitative parameters of meat production from Japanese quails. The obtained results were similar, and differences were not statistically significant.

The analysis of variance results evidenced that the tested factor did not influence the body weight gain of quails during the first 3 weeks of life. The coefficients evaluated the effect of the heating regimen as 0.2% of the total dispersion. The analysis by weeks showed that the used heating regimens had the least effect during the second weeks of life in quails: <0.1%.

Table 7. *Slaughter characteristics of 35- day old Japanese quails, % of body weight*

Indications	Groups		
	1 males	**2 males**	**3 males**
Carcass	65,05±0,39	65,48±0,68	64,38±0,59
Breast with bones	27,16±0,51	27,16±0,28	26,90±0,62
Thighs	18,02±0,24	18,08±0,66	17,48±0,09
Breast meat	21,79±0,66	20,20±1,09	22,02±0,64
Leg meat	13,67±0,22	13,78±0,58	13,37±0,10
Abdominal fat	0,31±0,07	0,28±0,13	0,30±0,14
	1 females	**2 females**	**3 females**
Carcass	64,03±0,79	64,08±1,04	63,98±1,41
Breast with bones	27,84±0,74	26,82±1,01	26,89±1,00
Thighs	16,98±0,32	17,64±0,49	16,77±0,46
Breast meat	21,91±0,92	20,72±1,22	21,50±1,04
Leg meat	12,89±0,33	13,24±0,34	12,77±0,49
Abdominal fat	0,29±0,19	0,24±0,10	0,34±0,16

DISCUSSION

The temperature is a key factor for the comfort of birds. Our results showed that the earlier the age, the higher its role for behavioral and physiological reactions was, as ambient temperature conditions influence the thermosensitivity of the hypothalamus and thus, determined the thermoregulation pattern at later stages of birds' life (9). This is particularly true between the 3rd and the 5th day of age that are the most critical for Japanese quails. By that time, they spend entirely the yolk reserves and satisfy their needs with nutrients of exogenous sources (5). Within the same time interval, the most intensive increase in the rate of food transport via the alimentary tract of birds is observed (10). That is why, during the first weeks of life of quails, every change in the rearing conditions, even imperceptible, could influence systemic physiological processes. The alternating temperature variations in the present study have probably exerted a stimulating effect upon the development of thermoreceptors in birds from experimental groups, although according to Baarendse et al., many other factors have an impact on successful thermoregulation in birds during the first days of life, among which the ratio of body volume to body area, as well as the degree of body thermal insulation by the embryonic down (9).

The location of cages in the premise and the regimen of turning heating on and off are mainly responsible for the variations in the minimum and maximum temperatures during the first week of the experiment. The lack of gathering of birds, especially during the early age periods, was indicative for apparently optimal temperature conditions. This thermal comfort was also demonstrated by the insignificant differences in productive traits between groups recorded up to the age of 7 days. The higher ratio between consumed feed and water in control birds during the first 7 days of life could be interpreted as a sign that this group was placed under ambient temperature that was slightly above the thermal comfort and consequently, quails drank more water.

The short periods when the heating was turned on and off, especially in quails from group 3, did not allow the rapid and easy adaptation to temperature in this group. Although between days 8 and 10 of life as well as throughout the preceding period, the birds have not gathered under the heat source, it could be assumed that probably, the quails from group 3 were at the boundary of thermal comfort and as a result, their growth was slower.

The reduction of heating time between the 15^{th} and the 17^{th} days of age in experimental quails and particularly in those from group 3, had a negative effect on the growth of birds. This is one of the crucial periods in the life of Japanese quails. By its end, the birds are almost completely covered with feathers (11). Thus, the efficiency of thermoregulation mechanisms in t his avian species is considerably improved due to the better thermoregulation from one part (9) and to fully functioning links between body thermal receptors and the brain of birds (2). Consequently, the dependence of Japanese quails on external heat sources significantly decreased and had a positive effect upon experimental birds.

The summarized results for the first three weeks of life of Japanese quails showed that constant temperatures, especially after the age of 10 days, could be a factor that delays growth rate. The lower feed consumption combined with its more efficient utilization as shown by experimental groups, are both an aspect of the more efficient meat production from Japanese quails. Similar are the conclusions of Afanasiev, who interprets this with the enhanced energy metabolism in birds reared under conditions of variable ambient temperatures (6). The role of temperature decreases, which in our experiments were not higher than 6.3 ^{o}C for the minimum temperatures should be therefore mentioned, whereas the data reported by Afanasiev et al., showed drops of 9-11 ^{o}C (4). Most probably, this is one of the main reasons for the author to reject the interrupted heating regimens as non-efficient and resulting in higher feed consumption and poorer feed conversion ratio (6).

The climatic conditions in Bulgaria allow the successful application of interrupted day and night heating regimens as confirmed by the results of this experiment. The regimens achieved 1.5 to 2 times higher energy savings compared to options where interrupted heating was applied only during the light hours of the day (4). Taking into consideration the fact that the costs of using various electric heating devices could account for up to 35% of the total costs (12), it could be concluded that the used regimens have the potential to reduce these costs by about one-third. The utilization of infrared quartz lamps is a far more effective means for heating of birds as in this case, the energy costs consist only 21% of the total rearing costs.

CONCLUSION

The application of interrupted heating regimens during the first three weeks of life in Japanese quails reared for meat production, did not have an effect on the vitality and the live body weight of birds at the age of 21 and 35 days. The tested factor did not influence the quantitative traits of produced meat. In the period between the 1^{st} and 21^{st} days of age, Japanese quails that were reared under interrupted heating regimens, have consumed by 2.3-5.4% less feed and by 3.4-5.1% less water on the average, whereas the feed conversion ratio was by 3.8-7.6% more efficient compared to quails reared at constant temperatures. Consequently to the application of interrupted heating regimens, the energy costs for heating of quails were reduced by 33.6-42% that, together with the lower feed expenditure and its better conversion, showed a potential for reduction of the total costs related to Japanese quail meat production by 28.7-36.5%.

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