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Chicken Hatching Syncronization for Artificial Incubation

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Abstract.

There are several stages of embryo development stipulated by qualitative structural changes and the subsequent growth periods. All these stages are synchronized. The periods when the development evolves into the growth are critical and most sensitive to external factors. Proper determination of such critical periods and the possibility to influence the embryogenesis by changing incubation temperatures may help to establish new incubation regimes. Managing the embryogenesis in the incubation period makes it possible to change the production level in the postembryonic period. Differential treatment shall change nutrition of embryos. In the first half of the incubation, glucose is supplied through the circulatory system as energy material for metabolic processes, and the energy metabolism may be shifted to using yolk lipids entering the intestine under the new regime. Chicken hatching synchronization is ensured by reducing the embryonic and hatching periods by 10–12 hours. The differentiated incubation regime may help to increase the growth of live weight of broilers during their rearing and reduce the feed efficiency ratio.

Keywords: incubation, embryogenesis, chicken uniformity, differentiation.

1. INTRODUCTION

In the past, when broilers were grown to the age of 56 days, the incubation duration made 27.3% of the term since the incubation start to the slaughter. At present, whereas the age of slaughter is reduced to 35 days, the incubation time has increased to 37.5%. Taking into account that the growing period for broilers is decreasing year by year, respectively, the incubation will be proportionally increased in general [1].

The quality of incubated chickens has a significant effect on broiler meat output and feed efficiency ratio. For example, high growth rates result in a decrease in the mass of bones, pen and brain of an embryo. Metabolic disorders, such as ascites, also begin in the embryonic phase [2]. Increasing the temperature by 1 °C (up to 38.5 °C) within the first three days of incubation significantly affects the mobility and weight of embryos, development of their muscles and bones of their limbs. Increased mobility of embryos caused by increasing the incubation temperature accelerates the development of their musculoskeletal system [3; 4]. When elaborating new incubation regimes or adjusting the existing ones, it is necessary to take into account the causes leading to death of embryos, two embryo death-rates have been found: within incubation days 4–6 and 18–20 [5]. The mortality rate increases as embryos grow during their incubation, and in the first days it is twice as high as during the hatching period. Due to "early dead", the mortality rate makes 0.1–0.5% on incubation days 1–2, 1.0–1.5% on incubation days 3–7, 1–2% on incubation days 8–18, and 3–4% on incubation days 19–21, respectively [6; 7; 8].

The first two days of incubation death rates of embryos are caused by interruption of differentiation and aniage (nervous system, sensory organs, axial skeleton). Some embryos stay alive, but abnormalities of their development usually cause their death in one of the subsequent critical periods [9]. In this regard, the priorities in developing incubation techniques are the elaboration of scientifically validated temperature and humidity incubation regimes, as well as creation of innovative incubator designs and incubation management systems that promote more complete realization of genetic potential of current high-yielding poultry [10; 11].

The hatching efficiency is largely predetermined by the uniformity of day-olds taken from the incubator. At the same time, uniformity is directly related to synchronization, i.e. with simultaneous initiation of the incubation for the whole batch of eggs, which leads to simultaneous start of embryonic development and, accordingly, to the smallest spread in the output. According to the relevant normative document, the sampling should be performed once after 21 days and 6 hours of incubation [12; 13]. Because of this, early hatched chicks are in the incubator much longer than the others, since the hatching may actually last more than a day even with the optimal quality of eggs and accurate observance of the incubation regime.

High uniformity of day-olds contributes to increasing the average daily growth and live weight to the age of slaughter, as well as the feed efficiency ratio, and reducing the mortality ratio. The production of uniform, healthy, well-developed chickens is especially important for broiler production, because every hour counts when growing chicken meat. In this regard, the role of the incubation of agricultural poultry significantly increases.

Therefore, it is of current interest to develop a technique to synchronize the hatching, which may help with increasing the broiler meat production. To achieve this goal, we used a differentiated incubation regime, based on the effect of high temperatures on embryos during critical periods of their growth.

2. METHODS

The *Ross 308 cross* eggs were used for the experiments. The experimental and control egg groups were formed by random sampling, 160 pieces each, by the method of paired analogues. The eggs were laid in Mossales incubators at the same time. As a control, the traditional incubation regime for table breeds was used (see Table 1).

A differentiated incubation regime was applied for the experimental group of eggs (see Table 2).

The study method provides for monitoring the hatching. In both groups, the pipping time, the total pipping growth, the hatching time for the first chicks in the batch and the mass hatching and completion thereof were taken into account. The hatching intensity was taken into account to determine the hatching timing. At the same time, the number of hatched chicks (in % of all hatched in the group) was determined at equal intervals in each group.

Table 1. Traditional Incubation Regime (Control Group)

Parameter	Incubator	
	setter	hatcher
Hygrometer readings, °C: dry thermometer wet thermometer	 37.6 29.0	 37.2 29.0 before the pipping, not regulated further
The position of ventilation flaps	Day 1–10 closed, Day 11–18 opened	Opened for 20–25 mm. Completely opened 3 hours before the sampling

Table 2. Differentiated Incubation Regime (Experimental Group)

Incubation time	Temperature requirements, °C	Wet thermometer, °C	Recommended flap position
To 23 hrs	37.6	30.0–32.0	The flap is closed
24-48	38.5 for 4 hrs and 38.0 further	30.0–32.0	The flap is closed
49-96 hrs	38.5	30.0–32.0	The flap is closed
97 hrs–day 13	37.5–37.6	29.0	The flap is closed up to day 7 and opened for 15–20 mm further
Day 14–17	37.2, and to set 38.5 for 4 hrs for each Day	29.0	The flap is opened for 30–35 mm
After day 18 up to the pipping	36.5–36.7	29.0 up to the pipping	The flap is opened for 15–20 mm

Table 3. Incubation Results for the Eggs Obtained from the Ross 308 Cross Table Breed Using Different Regimes

Parameter	Group	
	control	experimental
Number of incubated eggs, pcs.	160	160
Number of fertilized eggs, %/pcs.	93.8/150	93.8/150
Number of unfertilized eggs, %/pcs.	6.2/10	6.2/10
Failures, pcs.: early embryonic mortality blood ring dead-in-shell addled eggs	 4 2 4 3	 3 1 2 1
Hatchability, %	91.3	95.3
Output, %/pcs.	85.6/137	89.4/143
Live weight, g	41.6	40.4

3. Results

Table 3 shows the incubation results for the eggs obtained from the *Ross 308 cross* table breed at the age of 270 days. As in the earlier experiments with laying strains, the differentiated regime helped to increase the output and hatchability for table breeds too.

The differentiated incubation helps to increase the output by no less than 3.8% and the hatchability by 4.0% at $P \leq 0.95$. The growth of output and hatchability is mainly caused by the decreased incubation indices: “Dead Embryos”, “Blood Ring”, “Addled Eggs”, which corresponds to the conclusions of Payne, 1919 and Zabudsky, 1966. The experimental chickens had smaller live weight than those in the control group. The yolk sac and heart weights were also lower in the experimental group by 16.8% and 7.1%, respectively.

An important feature of good development of embryos is the duration of the incubation period. If an embryo eats well and develops, then its incubation period shall end in good time. If its development and metabolism are interrupted either due to certain egg inferiority, or inconsistency of the incubation regime with the embryo needs, in most cases this leads to an extension of the incubation period. In this case, the hatching shall cease later and last longer.

The duration of the incubation period in all bird species is predetermined by the evolution. Therefore, the entire process of artificial incubation should take place in the appropriate period for each bird species. However, within certain limits this period is variable and the hatching never occurs simultaneously. Approximately 29 hours passed both in the control and in the experimental groups from the beginning till the end of the hatching. The beginning is when the first chicks have pipped. The end of is when the last healthy chicks are taken out of the incubator, which do not need help to get rid of their eggshell. It should be borne in mind that these terms can be reduced or extended depending on the incubation regime used.

4. Discussion

The differentiated incubation regime used in the experimental group significantly changed the timing and synchronized the hatching. 100% of the chickens have pipped by the end of the incubation (regular 510 hours for table breeds). This new regime allows to synchronize the hatching. Thus, 73.0% of the chickens have pipped between incubation hour 490 and incubation hour 500 (see Figure 1). The peak pip with stable incubation regime has been stretched and the greatest pipping has come for incubation hours 500–508 (58.0%).

An egg is usually pipped closer to the blunt end of the egg, and the shell breaks off into large scraps. After the pipping, the embryo vigorously makes circular motions inside the egg. The shell membrane is elastic and torn as the shell is destroyed. Under the differentiated regime the pipping and the hatch are more concurrent and synchronized.

Both due to certain egg inferiority and improper environmental conditions any development interruption shall prolong the incubation period in most cases. As our study shows, timely hatch indicates that the incubated eggs are sound and the incubator conditions are proper for the embryos. Under this regime the pipping and the hatch began 21 hours earlier than if the stable regime was complied to. Under this new temperature regime the hatch ended 16 hours earlier than with the traditional one.

Table 4 presents the results of biochemical studies of blood taken from the heart of the experimental and control chickens on the first day after their hatch. The blood samples were taken before the first feeding.

The alkaline phosphatase in the blood of the experimental group has exceeded the indice of the control group more than 2.5 times. Such high value shows the increased role of the alanine glucose pathway with the release of glucose from the cells due to its dephosphorylation at high alkaline phosphatase levels. This indicates a lack of energy for the cells and proves that in order to compensate for the lost cell energy in the experimental group there is an intensive process of glucose synthesis and, most likely, from yolk lipoproteins.

A significant excess of cholesterol (2-fold) in the blood of the experimental group has been related to the intensive assimilation of yolk lipoproteins to obtain energy from embryos and ensure the vital functions of chickens. As a rule, this is due to relevant lack of high-density lipoproteins that prevent cholesterol deposition.

The low level of phosphorus in the blood of the experimental group is a clear evidence of the high metabolism in embryos and shortening of the life span of blood cells. Probably, the latter is a consequence of this process. This is evidenced by a slightly increased total bilirubin in this group.

Irrespective of the incubation regime, the creatinine in the blood of day-olds is significantly lower than the norm. It depends on the intake and assimilation of nutrients. Given that the chicks have not received food after the hatch, this may explain the low creatinine in the blood.

The level of glucose in the blood has been of our particular interest, as it is the main energy material for respiration of the embryo cells. Judging by the normative indices, hyperglycemia has been clearly observed in both groups. However, in this case we consider the values to be correct, since there are no standards for the glucose in the blood of chickens 12 hours after their hatch. At the same time, an increased glycaemic level may indicate the growing mobilization of glycogen from the liver.

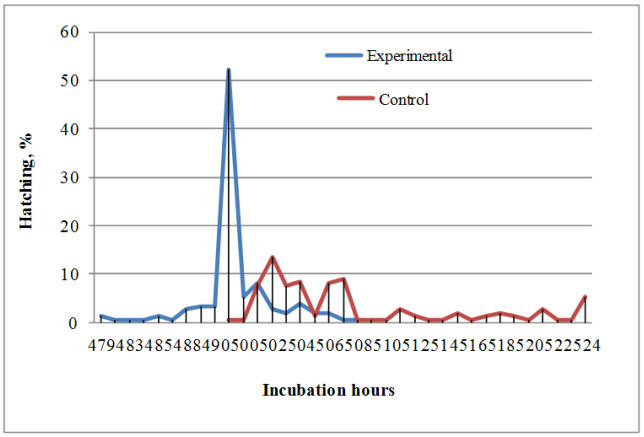

Figure 1. Hatching Dynamics under Different Incubation Regimes

Table 4. Biochemical Blood Indices of Day-Olds under Different Incubation Regimes

Parameter	Group		Performance indicators	
	experimental	control	min	max
Whole protein, g/l			43.0	60.0
Albumin, g/l	21.8	17.3	31.0	35.0
ALT, unit/l	20.4	29.4	*	*
AST, unit/l	355.0	553.1	*	*
LDH, unit/l	29.3	22.8	*	*
Amylase, unit/l	1422.3	1411.2	*	*
Alkaline phosphatase, unit/l	2146.0	833.0	*	*
Total bilirubin, µmol/l	7.9	7.2	0.2	1.7
Conjugated bilirubin, µmol/l	5.2	13.6	*	*
Cholesterol, mmol/l	9.4	4.7	2.8	5.2
BUN, mmol/l	2.2	1.8	2.3	3.7
Calcium, mmol/l	2.2	2.0	2.0	3.0
Creatinine, µmol/l	64.8	71.1	123.7	353.6
Phosphorus, mmol/l	1.4	2.0	1.8	2.4
Ferrum, mkg %	144.3	129.4	*	*
Magnesium, mmol/l	0.4	0.2	0.8	1.2
Glucose, mmol/l	11.0	9.2	4.4	7.8
Chlorides, mmol/l	74.1	72.3	*	*
Uric acid, µmol/l	200.0	427.0	44.0	108

Note: * not regulated for day-olds

Table 5. Live weight of Chickens Obtained from Eggs under Different Incubation Regimes (130 Birds in Each Group)

Age, days	Group	$M \pm m_M$, g	$\sigma \pm m_\sigma$, g	$C_v \pm m_{Cv}$, %
7th	control	89.8 ± 1.5	11.8 ± 1.1	13.1 ± 1.2
	experimental	88.13 ± 1.99	15.4 ± 1.4	17.5 ± 1.6
11th	control	166.5 ± 2.9	22.5 ± 2.1	13.5 ± 1.2
	experimental	166.6 ± 3.6	27.5 ± 2.5	16.5 ± 1.5
14th	control	300.1 ± 6.4	32.4 ± 4.5	10.8 ± 1.5
	experimental	309.8 ± 7.4	37.0 ± 5.2	11.9 ± 1.7
18th	control	495.0 ± 9.7	49.3 ± 6.8	10.0 ± 1.4
	experimental	535.0 ± 10.1	50.4 ± 7.1	9.4 ± 1.3
21st	control	678.0 ± 12.4	63.2 ± 8.8	9.3 ± 1.3
	experimental	697.0 ± 15.0	73.7 ± 10.6	10.6 ± 1.5
25th	control	1002.0 ± 19.8	101.0 ± 14.0	10.1 ± 1.4
	experimental	1047.0 ± 19.8	95.0 ± 14.0	9.1 ± 1.3
28th	control	1259.0 ± 23.1	118.0 ± 16.4	9.4 ± 1.3
	experimental	1367.0 ± 27.9	131.0 ± 19.7	9.6 ± 1.5
33rd	control	1733.0 ± 39.2*	200.0 ± 27.7	11.5 ± 1.6*
	experimental	1817.0 ± 44.3*	208.0 ± 31.4	11.4 ± 1.7*

Note: * — $P \leq 0.05$

In our opinion, the high temperature at different stages of the differentiated incubation regime led to increased evaporation of moisture from the eggs, which in turn has changed the energy metabolism towards more intensive use of lipids to create metabolic water that supports the aqueous homeostasis of the embryo, and glucose as an energy material has been spent less. Probably, one cannot ignore this reason for the increase in glycaemic level for the experimental chickens.

Chickens are hatched for 18–24 hours in an industrial incubator. They remain in the incubator until almost everyone leaves the shell. Extracted from the incubator, they undergo a whole series of treatments in the hatchery, and then they are transferred to the poultry house. In the industrial conditions, chickens remain without food and water for at least 36 hours. In addition, the duration of the hatching is also different, and young chicken do not receive neither feed nor water within this period. Such delay in feeding and drinking adversely affects intensity of their growth, formation of their immune system, stimulation of digestive enzymes, and development of their internal organs.

Improved strategies, including those referred to hatching and timing reduction, will provide an alternative to the negative effects of delayed first feeding [14; 15; 16; 17; 18].

All the young (after their hatching) were put in a cellular rearing battery at the vivarium of the Kuban State University, where the chickens have been weighed on a regular basis until the age of 33 days.

It should be noted that for the entire rearing period, the same number of deaths has been observed in the experiment and in the control group (2 chicks in each group). The reasons for their death have not been examined.

The data obtained within the test show that the live weight in the experimental group has exceeded the live weight of the chickens hatched under the traditional incubation regime for all the ages (see Table 5).

At the end of the rearing period the difference in weight was more than 5% in the experimental group. The average daily gain for the entire rearing period was 55.1 g in the experimental group and 52.5 g in the control group. The experimental chickens had the edge over the control for their keel bone and stomach and liver weights.

5. Conclusion

In the most important stages of embryogenesis, relevant high temperatures applied under the differentiated incubation regime contributed not only to some acceleration of the embryonic development, but also had a positive effect on the growth in the postnatal period. The studies highlight the discreteness of the stages of embryogenesis. Each stage corresponds to certain qualitative changes in embryogenesis. A *corpus pineale* seems to be the place where embryogenesis starts, the secretory cells of which are already detached by the end of incubation day 1. A corpus pineale, being the body's clock, sets the rhythm of embryogenesis. Before incubation day 11 an embryo is a typical poikilothermic animal, the development of which depends on the environment temperature. Elaboration of incubation regimes in which the temperature sets the stages and rhythm of embryogenesis is a promising solution to accelerate embryonic development, thereby improving the hatching.

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