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New Suggested Schemes for Incubation Temperature and Their Effect on Embryonic Development and Hatching Power

[1]Nadia A.M. Elsayed, [1]Alaa E. Elkomy, [2]Amina [1]S. El-Saadany and [1]Effet Y. Hassan
[1]Animal Production Research Insititue, Agriculture Research Center,
Ministry of Agriculture, Egypt
[2]Arid Lands Cultivation and Development Research Institute,
Mubarak City for Scientific Research and Technology Applications, Egypt

Abstract: The present study was to investigate two suggested schemes of incubation temperatures and their effect on hatching power and embryonic development of two local Egyptian chicken strains. Twelve hundred fertile egg (600 from each strain) were used in this experiment that distributed on the control and two suggested schemes. The traditional incubation scheme (program 1) was used as a control and fixed during incubation period (0-18 days) with 37.5°C and the suggested schemes incubation temperature (program 2 and 3) was 37.5°C from 0-14 days and then raised up to 39.5 or 40.7°C for 3 h daily till the 18th day (15th-17th day) for the first program and the second suggested schemes (programs 2 and 3) respectively. During the hatching period (19-21 days), the hatching temperature was 37°C for all three programs. Relative humidity was 55% during the incubator period for all three programs and 65% for the hatching period. Suggested programs (2 and 3) resulted in a significant increase embryo weight at 18th day of incubation and chick weight at pull out ($p \leq 0.05$) and the two programs produced chicks with a higher body weight than the program 1. There was a significant decrease in yolk sac weight in the programs 2 and 3 that associated with a significant increase in plasma total lipid ($p \leq 0.01$). Relative liver weight was decreased significantly ($p \leq 0.05$) with increase incubation temperature at both study periods and the hepatic glycogen was taken the same trend. Plasma calcium level was increased significantly ($p \leq 0.01$) at hatching time in the two suggested programs (2 and 3) compared to the program 1 that reflected on increase tibia relative weight. A gradual and significant increase in serum T_3 concentration ($p \leq 0.05$) was found in the programs 2 and 3 compared to the control program. Increasing incubation temperature in the programs 2 and 3 caused a decrease hatching period compared to the program A, as well as the hatchability percentage (%) was increased significantly ($p \leq 0.01$) and this increase was noticed in both the two strains.

Key words: Hatcher temperature, plateau stage, hatchability percentage, embryonic development, thyroid hormone

INTRODUCTION

The artificial incubation of eggs of domesticated species can now be carried out with a high degree of success. However, advances in understanding about the problems faced by the developing embryo during incubation are still being made. The process of incubation is both complicated and remarkable: complicated, because it involves a developmental process capable of transformation a chemical mixture of yolk and albumin into a living chick; remarkable, because in spite of its complexity, it proceeds correctly more times than it goes wrong (Tullet, 1990).

Corresponding Author: Alaa Elsayed Elkomy, University and Research Center District, New Bourg El-Arab, Alexandria, P.O. Box 21934, Egypt

Temperature is the most critical physical factor of artificial incubation affecting hatchability and plays an important role in embryonic development (Bagley, 1987). Embryos are sensitive to lower or higher incubation temperature, the lower incubation temperatures depress and the higher incubation temperature accelerate growth and development (Ricklefs, 1987). Most poultry species have an optimal temperature for hatching success (Christensen *et al*., 1994; Decuypere, 1994). French (1997) reported that the temperature experienced by developing embryo is dependent on the incubation temperature and the metabolic heat production of the embryo. Rizk *et al*. (2004) stated that hatchability of fertile eggs was numerically increased by 99.5 F° compared with 98.6 F° of local chicken strain. Joseph *et al*. (2006) stated that lower temperature in the first 10 days of incubation reduced hatchability, while, higher temperature in the hatcher increased total hatchability. Hulet *et al*. (2007) reported that incubation temperature has a great effect on chick weight at hatch.

It is well know that the optimal temperature is the primary concern in the achievement of satisfactory hatching results (Landauer, 1967). For many domesticated species the amount of egg weight loss is around 12-14% of initial egg mass by pepping time (Tullet, 1990; Soliman, 2000). Shahein (2002) reported that incubation temperature has a main effect on egg weight loss and hatch time.

The timing of thermal manipulation has to be linked to the development of the hypothalamus-hypophysis-thyroid axis to change the heat production threshold response, while the temperature experienced prenatal by embryos has a clear influence on postnatal hypothalamic thermosensitivity (Tzschentke and Basta, 2002; Yahav *et al*., 2004). Yahav *et al*. (2004) reported that increasing the temperature during the period from 16 to 18 days of the embryo age would result to improve hatching percentage. Embryonic plasma thyroid hormone concentrations were closely related to hatchability temperature and basal metabolism (Christenes *et al*., 1982). Also, they reported elevated T_4 and T_3 concentration foster increased survival rates.

Aim of this study is to investigate two suggested schemes for incubation temperatures in comparison with the traditional incubation scheme and their effect on embryonic development and hatching power of two local chicken strains (Mandara strain as a type of egg production chicken and Gimmizah strain as a type of meat production chicken) with ages 40 weeks.

MATERIALS AND METHODS

This study was carried out at El-Sabahia Poultry Research Center (Alexandria), Animal Production Research Institute, Agriculture Research Center.

Aim of this study to investigate two suggested schemes for incubation temperatures in comparison with the traditional incubation scheme and their effect on embryonic development and hatching power on two local chicken strains (Mandara strain as a type of egg production chicken and Gimmizah strain as a type of meat production chicken) with age 40 weeks.

Single stage incubator with capacity of 1000 hatching eggs was used in this experiment. Incubator equipped with electronics temperature and humidity apparatuses. Twelve hundred fertile egg (600 from each strain) were used in this experiment that distributed on the control and two suggested schemes. Fertile eggs were collected daily from floor pens and stored at room controlled in its temperature for 5 days till the time of incubation.

Two hundred fertile eggs from each strain were used for each program without any significant differences between laid eggs weights at the start of incubation. The time of setting eggs in the incubator was recorded exactly to obtain the exact hatch time in hours. Eggs from each strain were randomly divided into three groups that set at different places in the incubator to avoid the position effect.

The temperature schemes are shown in Fig. 1. The traditional incubation scheme (program 1) was used as control and fix during incubation period (0-18 days) with 37.5°C. The first suggested scheme was used as the program 2 with incubation temperature 37.5°C from (0-14 days) and then raised up to 39.5°C for 3 h daily till the 18th day (15th-17th day). The second suggested scheme was used as

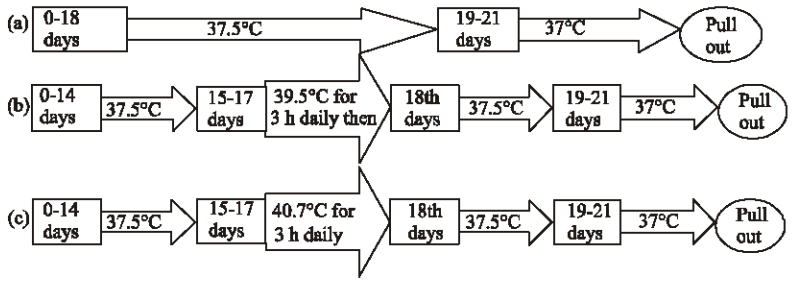

Fig. 1: The temperature schemes for control, first program and second program; (a)1st, (b) 2nd and (c) 3rd program

a program 3 with incubation temperature 37.5°C from (0-14 days) and then raised up to 40.7°C for 3 h daily till the 18th day (15th-17th day). During the hatching period (19-21 days), the hatching temperature was 37°C for all three programs. Relative humidity was 55% during the incubator period for all three programs and 65% for the hatching period.

Eggs were weighed at the 14th and 18th day of incubation to determine the egg weight loss percentage. At the 19th day of incubation, all eggs were transferred individually into pedigree hatching baskets and then set into the hatcher for the hatching period of the incubation. The time was recorded when the chick was began to pepping the shell of egg, as well, when the chick completely emerged from eggshell. The newly hatched chicks were wing-banded and weighed to the nearest 0.1 g; this weight was recorded as chick body weight at hatch then putted again in the hatcher after recording the time of the hatch. Body weight and hatching time were recorded every 2 h. All chicks were weighed again at the pull time from the hatcher:

Chick body weight loss during incubation expressed on a percentage basis was calculated according to the following equation of Shahein (2002):

$$\text{Chick weight loss (\%)} = \frac{\text{Chick weight at hatch- chick weight at pull out}}{\text{Chick weight at hatch}} \times 100$$

The percentage of hatchability was calculated as:

$$\text{Hatchability (\%)} = \frac{\text{Total number of hatched chick}}{\text{Total number of egg set}} \times 100$$

At the 18th day of incubation period 10 eggs from each strain under each program were broken to record the embryo weight and also to obtain blood samples from hearts of embryos, in addition, the liver and yolk sac were removed and weighed. As well as, 10 chicks at pull out from each strain under each program were sacrificed to obtain blood samples and the liver, tibia and yolk sac were removed and weighed.

Blood samples were collected in the clean tubes and centrifuged at 3000 rpm for 20 min to obtain plasma and stored at -20°C for later biochemical analysis. Plasma glucose, total protein, total lipids and calcium levels were estimated according to Trinder (1969), Armstrong and Carr (1964), Frings *et al*. (1972) and Sarkar and Chauhan (1967), respectively. Alkaline phosphatase enzymes activity was estimated.

Statistical Analysis

Data for the present studies were statistically analyzed for ANOVA using the General linear model of MSTAT-C (1989). Duncan's multiple range tests was used to detect any significant differences among the experimental means.

RESULTS AND DISCUSSION

Egg Weight and Egg Weight Loss Percentage

Data presented in Table 1 revealed that no significant differences between suggested hatching programs (programs 2 and 3) and control (program 1) or between two different strains in the average value of initial egg weights.

There was a non-significant decrease ($p \leq 0.05$) in egg weights at 18th day of incubation period of the programs 2 and 3 than the program 1 for both Gimmizah and Mandarah strain. Furthermore, the data shown in Table 1 showed increasing the percentage of egg weight loss significantly ($p \leq 0.05$) in the programs 2 and 3 compared to the program 1. It appears from this investigation that egg weight loss has been affected significantly due to change incubation temperature. On the other hand, no effect was found according to strain on this parameter.

For many domesticated species the amount of egg weight loss is around 12-14% of initial egg mass by pepping time (Tullet, 1990; Soliman, 2000). Shahein (2002) reported that eggs incubated at temperature of 40°C lost significantly ($p \leq 0.05$) more weight than that incubated at either 37 or 37.5°C.

Embryo Weight at 18th Day of Incubation, Pull Out and Chick Weight Loss Percentage

From Table 2, it can be seen that, increasing incubation temperature that used in the program 2 and 3 resulted in increase embryo weight at 18th of incubation and chick weight at pull out from hatch and this effect was significantly ($p \leq 0.05$) compared with the program 1. As well, the program 3 produced chicks with a higher body weight than the program 2. These results had a similar trend in both different stains. At 18th of incubation, no difference between Gimmizah and Mandarah strain on the embryonic weight, while, at the hatching time Gimmizah strain had chick body weights significantly higher ($p \leq 0.05$) than the other strain.

Ricklefs (1987) revealed that the higher incubation temperature accelerate growth and development. Shahein (2002) reported that embryo weight was increased significantly ($p \leq 0.05$) from egg incubated at 40°C compared to those incubated at 37 or 37.5°C at 14 and 18 day of incubation. And this effect of temperature due to that the temperature is the most physical factor of artificial incubation affecting hatchability and plays an important role in embryonic development (Shahein, 2002; Rizk *et al*., 2004). Hulet *et al*. (2007) reported that incubation temperature has a great effect on chick weight at hatch.

Data of chick weight loss percentage at pull out (Table 1) revealed that no significant ($p \leq 0.05$) differences were found between suggested programs (2 and 3) and program 1 or between the two strains in chick weight loss percentage, in spite of, the program 3 recorded the highest percentage for

Table 1: Effect of increasing incubation temperature on egg weight and egg weight loss (%) at 18th of incubation period and chick weight loss (%) at pull out

		Programs			
Traits	Strain	1	2	3	Over all mean
Initial	Gimmiazah	55.75±0.42^{ns}	55.60±0.44^{ns}	55.87±0.45^{ns}	55.74±025^{ns}
	Mandarah	54.95±0.39^{ns}	55.55±0.36^{ns}	55.42±0.42^{ns}	55.30±0.22^{ns}
Over all mean		55.85±0.30^{ns}	55.57±0.29^{ns}	55.64±0.31^{ns}	
Egg weight at 18th day	Gimmiazah	52.10±0.42^{ns}	51.65±0.42^{ns}	51.60±0.41^{ns}	51.78±0.22^{ns}
	Mandarah	51.62±0.40^{ns}	51.18±0.33^{ns}	51.12±0.42^{ns}	51.30±0.26^{ns}
Over all mean		51.86±0.28^{ns}	51.42±0.27^{ns}	51.36±0.32^{ns}	
Egg weight loss (%)	Gimmiazah	6.54±0.28^{b}	7.07±0.38^{a}	7.64±0.18^{a}	7.08±0.22^{ns}
at 18th day	Mandarah	6.06±0.19^{b}	7.86±0.40^{a}	7.75±0.19^{a}	7.05±0.17^{ns}
Over all mean		6.30±0.26^{b}	7.46±0.27^{a}	7.69±0.17^{a}	
Chick weight loss	Gimmiazah	5.62±0.64^{ns}	6.34±0.32^{ns}	6.63±0.51^{ns}	6.19±0.27^{ns}
at pull out	Mandarah	5.55±0.35^{ns}	6.45±0.34^{ns}	6.69±o.54^{ns}	6.23±0.29^{ns}
Over all mean		5.63±0.25^{ns}	6.39±0.28^{ns}	6.65±0.37^{ns}	

Values are expressed as Mean±SE; Mean values within a same row with different superscript are significantly different at $p \leq 0.05$. ^{ns}: Not significant

Table 2: Effect of increasing incubation temperature on 18th chick weight, Yolk sac weight, relative liver weight and hepatic glycogen at 18th day of incubation period and hatch pull out

Traits		Strain		
Parameters	Programs	Gimmiazah	Mandarah	Over all mean
At 18th day				
Chick weight	1	18.62±0.56^{c}	18.57±0.85^{c}	18.59±0.60^{b}
	2	18.74±1.04^{c}	19.74±1.05^{bc}	19.24±0.59^{b}
	3	21.89±0.52^{a}	22.19±0.37^{a}	22.04±0.41^{a}
Over all mean		19.75±0.65^{ns}	20.16±0.80^{ns}	
Yolk sac weight	1	9.13±0.50^{ab}	12.06±0.20^{a}	10.59±0.13^{a}
	2	8.62±0.21^{b}	9.06±0.33^{ab}	8.84±0.23^{b}
	3	7.95±0.30^{b}	8.28±0.48^{b}	8.11±0.29^{b}
Over all mean		8.57±0.41^{ns}	9.80±0.83^{ns}	
Relative liver weight	1	2.61±0.03^{a}	2.43±0.15^{ab}	2.52±0.08^{a}
	2	2.32±0.08^{ab}	2.29±0.12^{ab}	2.35±.04^{b}
	3	2.12±0.11^{b}	2.28±0.05^{b}	2.20±0.08^{b}
Over all mean		2.35±0.08^{ns}	2.33±0.06^{ns}	
Hepatic glycogen	1	4.75±0.77^{ns}	4.93±0.34^{ns}	4.84±0.38^{ns}
	2	4.48±0.25^{ns}	4.37±0.06^{ns}	4.42±0.22^{ns}
	3	3.88±0.07^{ns}	4.33±0.27^{ns}	4.11±0.16^{ns}
Over all mean		4.37±0.29^{ns}	4.54±0.16^{ns}	
At pull out 21st day				
Chick weight	1	41.53±0.38^{c}	40.16±0.48^{d}	40.94±0.30^{b}
	2	43.14±0.42^{ab}	40.97±0.41^{cd}	42.04±0.31^{a}
	3	43.36±0.42^{a}	42.04±0.36^{ab}	42.79±0.23^{a}
Over all mean		42.62±0.22^{a}	41.10±0.25^{b}	
Yolk sac weight	1	4.29±0.67^{ab}	6.01±0.17^{a}	5.15±0.17^{a}
	2	4.03±0.70^{b}	5.90±0.38^{a}	4.96±0.49^{a}
	3	3.30±0.60^{b}	4.67±0.6^{ab}	3.98±0.44^{b}
Over all mean		3.87±0.36^{b}	5.52±0.27^{a}	
Relative liver weight	1	2.94±0.06^{a}	2.65±0.19^{ab}	2.79±0.11^{a}
	2	2.68±0.22^{ab}	2.49±0.20^{ab}	2.58±0.14^{ab}
	3	2.39±0.11^{ab}	2.09±0.21^{b}	2.24±0.13^{b}
Over all mean		2.67±0.11^{ns}	2.41±0.13^{ns}	
Hepatic glycogen	1	4.48±0.13^{a}	4.40±0.07^{ab}	4.44±0.07^{a}
	2	3.88±0.08^{bc}	4.18±0.13^{b}	4.03±0.13^{b}
	3	3.81±0.22^{c}	3.73±0.27^{c}	3.77±0.13^{b}
Over all mean		4.06±0.13^{ns}	4.11±0.13^{ns}	

Values are expressed as Mean±SE; Mean values within a same row with different superscript are significantly different at $p \leq 0.05$. ^{ns}: Not significant

chick weight loss. Thus the over all means for incubation programs were 5.58, 6.39 and 6.65% for the programs 1, 2 and 3, respectively. And those were 6.19 and 6.23% for Gimmizah and Mandarah strain, respectively. Hager and Bean (1983) mentioned that chicks were heavier and growing faster when they removed soon after hatching (less than 6 h after becoming sufficiently dry) and provided with water and feed than that later hatching. Wayatt *et al*. (1985) found that chicks' body weight was reduced with increase the time between hatch and placement.

Yolk Sac Weight, Liver Relative Weight, Tibia Relative Weight and Liver Hepatic Glycogen Content

From Table 2 it can be concluded that increasing incubation temperature with the two suggested schemes (programs 2 and 3) caused a decrease in yolk sac weight at both studied interval periods compared to the program 1 and this decrease was significant ($p \leq 0.05$). In addition, the results showed that the decreasing yolk sac weight was higher in the program 3 than the program 2. Yolk sac weight seemed to be lower in Gimmizah strain compared with Mandarah strain at both 18th day of incubation and pull out from hatch and this effect was significant ($p \leq 0.01$) at pull out time only. Decreasing yolk sac weight which occurred in the programs 2 and 3 may be due to stimulate fat absorption of yolk sac lipid and activate fat metabolism (lipolysis) to produce energy, since, plasma total lipids level was increased in the suggested programs compared to the control (Table 3).

Table 3: Effect of increasing incubation temperature on plasma glucose concentration (mg dL^{-1}), plasma total protein concentration (g dL^{-1}) plasma total lipids concentration (g dL^{-1}), T_3 hormone concentration (ng dL^{-1}) and alkaline phosphatase enzyme activity at 18th day of incubation period and hatch pull out

Traits		Strain		
Parameters	Programs	Gimmiazah	Mandarah	Over all mean
At 18th day				
Plasma glucose concentration	1	75.830±9.8^{b}	76.600±8.5^{b}	76.22±5.8^{b}
	2	100.760±3.7^{a}	99.390±2.2^{a}	100.07±1.2^{a}
	3	105.930±4.9^{a}	119.720±8.2^{a}	112.830±5.9^{a}
Over all mean		94.170±5.6^{ns}	98.570±7.3^{ns}	
Plasma total protein concentration	1	3.430±0.32^{ns}	2.260±0.19^{ns}	2.850±0.31^{b}
	2	3.800±0.66^{ns}	3.300±0.79^{ns}	3.550±0.37^{ab}
	3	4.660±0.28^{ns}	3.690±1.13^{ns}	4.170±0.38^{a}
Over all mean		3.960±0.29^{ns}	3.080±0.31^{ns}	
Plasma total lipids concentration	1	2.142±0.53^{b}	2.386±0.11^{c}	2.264±0.25^{c}
	2	6.796±1.08^{a}	8.220±1.27^{b}	7.718±0.63^{b}
	3	7.215±0.36^{a}	13.445±0.52^{a}	10.120±1.58^{a}
Over all mean		5.384±0.89^{b}	8.017±1.64^{a}	
T_3 hormone	1	0.610±0.01^{b}	0.590±0.01^{b}	0.600±0.01^{c}
	2	0.680±0.01^{a}	0.610±0.02^{b}	0.650±0.02^{b}
	3	0.710±0.01^{a}	0.690±0.003^{a}	0.700±0.01^{a}
Over all mean		0.670±0.01^{a}	0.630±0.02^{b}	
Alkaline phosphatase activity	1	33.630±1.53^{ab}	25.350±2.10^{b}	29.490±2.09^{b}
	2	37.570±2.43^{a}	36.360±2.10^{a}	36.970±1.46^{a}
	3	38.180±5.45^{a}	39.080±2.62^{a}	38.510±3.09^{a}
Over all mean		36.460±1.87^{ns}	33.600±2.39^{ns}	
At pull out 21st day				
Plasma glucose concentration	1	166.280±2.1^{b}	167.730±2.4^{b}	167.00±1.4^{b}
	2	169.010±3.4^{ab}	175.170±5.5^{ab}	172.09±3.2^{ab}
	3	173.740±4.4^{ab}	181.190±4.1^{a}	177.46±3.1^{a}
Over all mean		169.680±2.0^{ns}	174.700±2.8^{ns}	
Plasma total protein concentration	1	2.680±0.04^{ns}	2.530±0.08^{ns}	2.611±0.05^{ns}
	2	2.710±0.26^{ns}	2.730±0.06^{ns}	2.720±0.16^{ns}
	3	2.980±0.12^{ns}	2.800±0.25^{ns}	2.890±0.08^{ns}
Over all mean		2.790±0.09^{ns}	2.680±0.08^{ns}	
Plasma total lipids concentration	1	13.190±0.44^{ns}	13.190±1.76^{ns}	13.190±0.80^{ns}
	2	13.410±1.02^{ns}	14.150±1.65^{ns}	13.780±0.88^{ns}
	3	13.790±0.19^{ns}	14.940±0.76^{ns}	14.360±0.55^{ns}
Over all mean		13.460±0.33^{ns}	14.090±0.77^{ns}	
T_3 hormone	1	0.640±0.04^{b}	0.620±0.01^{b}	0.630±0.02^{b}
	2	0.700±0.01^{a}	0.650±0.02^{b}	0.680±0.02^{a}
	3	0.700±0.1^{a}	0.660±0.02^{a}	0.680±0.01^{a}
Over all mean		0.680±0.01^{ns}	0.605±0.1^{ns}	
Alkaline phosphatase activity	1	41.210±3.21$^{n>s}$	38.780±3.37$^{n>s}$	40.050±2.03$^{n>s}$
	2	41.210±3.69$^{n>s}$	39.390±3.03$^{n>s}$	40.300±2.17$^{n>s}$
	3	44.240±5.39$^{n>s}$	39.990±3.15$^{n>s}$	42.150±3.09$^{n>s}$
Over all mean		42.220±2.16$^{n>s}$	39.390±1.60$^{n>s}$	

Values are expressed as Mean±SE; Mean values within a same row with different superscript are significantly different at $p \leq 0.05$. ^{ns}: Not significant

Data of liver relative weight that presented in Table 2 revealed that there was a gradual and a significant ($p \leq 0.05$) decrease in relative liver weight with increase incubation temperature and this decrease was an incubation temperature dependent manner. On the other hand, there was no effect for strain on this point.

The decrease which found in liver relative weight was associated with decrease hepatic liver glycogen content (Table 2), whereas, the liver glycogen content was taken the same trend of relative liver weight, but this effect was significant ($p \leq 0.05$) during the hatch period only. This decrease in liver glycogen content that induced with increasing incubation temperature may be due to the activation of hepatic enzyme systems that are intimately involved in glycogen degradation (glucogenesis) to glucose, since, the blood glucose level was significantly increased (Table 3). These results presented herein are in the line with that of Christensen *et al.* (2003), who indicated that liver weight influence by

Table 4: Effect of increasing incubation temperature on relative tibia weight and plasma calcium concentration (mg dL^{-1}) at hatch pull out

Traits		Strain (at pull out 21 day)		
Parameters	Programs	Gimmiazah	Mandarah	Over all mean
Plasma calcium	Control	5.35±0.29^{ns}	5.32±0.20^{ns}	5.33±0.22^{b}
	1	5.39±0.30^{ns}	5.58±0.32^{ns}	5.49±0.29^{b}
	2	6.24±o.57^{ns}	6.24±0.56^{ns}	6.24±0.50^{a}
Over all mean		5.66±0.18^{ns}	5.71±0.17^{ns}	
Relative tibia weight	Control	0.33±0.12^{ns}	0.32±0.008^{ns}	0.32±0.008^{b}
	1	0.35±0.012^{ns}	0.34±0.021^{ns}	0.35±0.011^{b}
	2	0.38±0.024^{ns}	0.41±0.013^{ns}	0.40±0.013^{a}
Over all mean		0.35±0.12^{ns}	0.36±0.15^{ns}	

Values are expressed as Mean±SE; Mean values within a same row with different superscript are significantly different at $p \leq 0.05$. ^{ns}: Not significant

incubation temperature along with hepatic glycogen. Also, they concluded that embryos which have highly glucose concentration grew faster than those have lowly glucose concentration.

Tibia relative weight (Table 4) at hatching time was increased by increase incubation temperature that used in the programs 2 and 3 compared to the program 1 and this effect was significantly ($p \leq 0.01$) by the program 3 only. Increased tibia relative weight was associated with increased plasma calcium level (Table 4) that had the same trend and this increase reflected on increased tibia weight.

Some Blood Biochemical Parameters

Plasma glucose concentration (Table 3) was significantly higher ($p \leq 0.01$) with the two suggested programs (2 and 3) compared to the program 1 at both 18th day of incubation and at pull out time. As well as, this increase in plasma glucose concentration was in an incubation temperature dependent manner; in addition, plasma glucose level at pull out time appeared to be higher than at 18th day of incubation. On the other side, strain did not affect on plasma glucose level at both interval periods. Blood glucose concentration with programs 2 and 3 were increased at the same time hepatic glycogen content (Table 2) was decreased. Increase blood glucose concentration may be due to the activation of hepatic enzymes system which is intimately involved in glucose production. Christensen and Davis (2001) revealed that environmental and genetics factors interacted and affected embryonic thyroid functions. Christensen *et al.* (2003) concluded that embryos which have highly glucose concentration grew faster than those have lowly glucose concentration. Christensen *et al.* (1982, 2003) showed that elevation of T_3 was associated with greater blood glucose concentration. As well, hatching chick weights were highly significant and positively correlated with blood glucose concentration at hatching (Christensen *et al.*, 2003).

Over all means at 18th day of incubation and hatching time (Table 3) indicated that, increased incubation temperature by suggested schemes caused a gradual rising for plasma total protein level and this effect was significantly ($p \leq 0.05$) during 18th day of incubation only. Also, there was a non-significant effect for strain on plasma total protein level, since; Gimmizah strain had plasma total protein level slightly higher than Mandarah strain.

Thermal manipulation that used in the present study caused an increase in plasma total lipids (Table 3) compared to control program and this effect was found at both interval study periods, which was highly significant ($p \leq 0.01$) at 18th day of incubation only. Increase plasma total lipids were associated with a decrease in yolk sac weight in the thermal suggested programs and this effect may be due to stimulate fat absorption from sac yolk and activate fat metabolism. Effect of strain on plasma total lipids was found, since, the Mandarah strain had plasma total lipids level higher than Gimmizah strain and this increase was significantly ($p \leq 0.01$) at 18th day of incubation only.

Increase incubation temperature may be affected on increase calcium absorption from egg-shell to embryo blood, since, plasma calcium level (mg dL^{-1}) (Table 4) was increased in the programs 2 and

3 than the program 1 and this effect was significantly ($p \leq 0.01$) with the program 3 only. This increase in plasma calcium level was reflected on increase tibia relative weight, which increased at the same manner and this increase refer to enhance calcium transfer from blood to skeletal bone. On the other hand, the effect of strain on plasma calcium was not found, since, plasma calcium level did not differ between the two strains.

Embryos that subjected to raise incubation temperature revealed a gradual and significant increase ($p \leq 0.05$) in their serum T_3 concentration compared to the control embryos and this effect was incubation-temperature dependent manner (Table 3). Also, from the data it can be noticed that increasing T_3 hormone level in the programs 2 and 3 may be due to enhancing the carbohydrate metabolism, since; this result was associated with raising blood glucose concentration and glycogen degradation (glucogensis). On the other side, Gimmizah strain had T_3 hormone level higher than Mandarah strain and these differences were significant ($p \leq 0.05$) at 18th day of incubation only. Christensen *et al*. (2002) explained that in embryonic avian, thyroid hormone has two effects development and metabolic, also, they reported the environmental factors can affected circulating thyroid hormone level in avian embryo thus affecting metabolic function and possibility exist to manipulate to improve hatchability. Present results are in agreement with the results of Christensen *et al*. (1982, 2003) how reported that elevation of T_3 was associated with increased blood glucose concentration. And this increase in carbohydrate metabolism was significantly and positively correlated with increase hatching chick weights and hatching rate (Christensen *et al*., 2003).

Thermal manipulation which suggested in this study led to increase in alkaline-phosphatase activity (Table 3) in both the programs 2 and 3 compared to the program 1 and this increase was statistical significance ($p \leq 0.01$) at 18th day of incubation only. In addition, the program 3 had higher alkaline-phosphatase activity than the program 2 without any significant between them. As well, there were differences between strains in alkaline-phosphatase activity, since; Gimmizah strain had the higher alkaline-phosphatase means at 18th day of incubation or at pull out time. Increasing of metabolism and brain activity in embryos at 18th day of incubation resulted in increase alkaline-phosphatase and this effect may be due to the thermal manipulation during embryo development and this effect could be seen clearly in the program 3.

Hatch Time and Hatchability Percentage

Increasing incubation temperature in the two suggested schemes program 2 and 3) caused a decrease hatching period compared to the program 1 (Fig. 2, 3) and this effect was taken a similar trend in both Gimmizah strain (Fig. 3) and Mandarah strain (Fig. 4). It is means embryos subjected to the programs 2 and 3 were hatched at period shorter than the program 1 and this time was by 10 h for the program 2 and 8 h for the program 3 in the Gimmizah strain but it was 16 h and 18 h, respectively in Mandarah strain. Decreasing hatch period and chick weight loss resulted in increase incubation temperature were reflected on increase newly chick weight. Wayatt *et al*. (1985) reported that time of hatch was important because chicks held in incubation trays for 14-32 h post-hatch lost 5-12% from their weight than chicks removal promptly and this reduction in weight persisted to 49 day of age. Also, Stikeleather and Brake (1990) reported, chick weight was directly related to the time of hatch and to the holding time within the incubation. The differences in hatch time between Gimmizah and Mandarah strains may be due to genetics variation between them and this observation was in agree with that of Christensen *et al*. (2000) how reported that a differences in length on incubation period due to genetic variation has been observed in chickens.

From Fig. 2, increase temperature during the last three days of incubation period conducted to a gradual and significant raise ($p \leq 0.01$) in hatchability percentage (%) and this increase was noticed in both Gimmizah and Mandarah strains. Hatchability percentage means of Gimmizah strain were 87.7

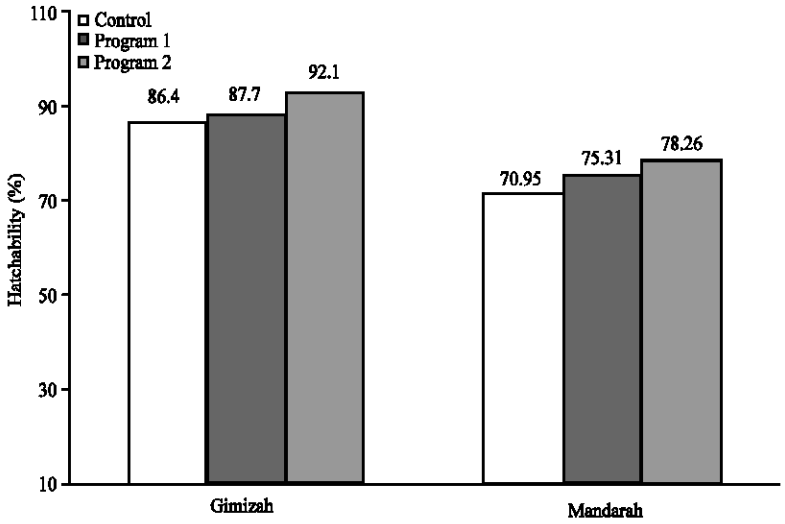

Fig. 2: Effect of increasing incubation temperature on hatchability percentage (%)

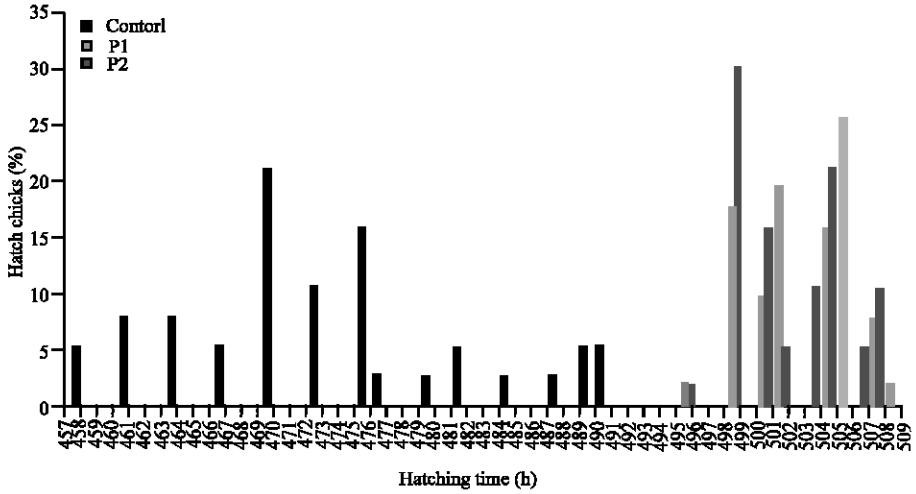

Fig. 3: Effect of increasing incubation temperature on hatch time (h) for Gimmizah strain

and 92.1% for the programs 2 and 3 respectively vis 86.4% in the program 1 and those were 75.3 and 78.2% vis.70.9% for Mandarah strain. The difference in hatchability percentage that found between two strains may be due to the genetic variation between them. Present results are in agreement with that of Rizk *et al*. (2004) who stated that hatchability of fertile eggs was numerically increased by 37.5°C compared with 37°C of local chicken strain. Yahav *et al*. (2004) reported that increasing the temperature during the period from 16 to 18 days of the embryo age would result to improve hatching percentage. Joseph *et al*. (2006) stated that lower temperature in the first 10 days of incubation reduced hatchability, while, higher temperature in the hatcher increased total hatchability. Most poultry species have an optimal temperature for hatching success (Christensen *et al*., 1994; Decuypere, 1994).

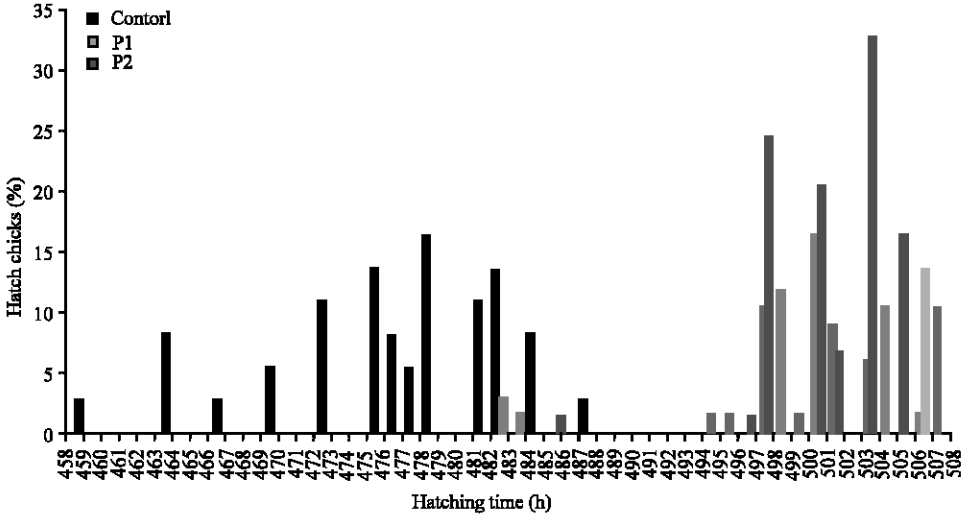

Fig. 4: Effect of increasing incubation temperature on hatch time (h) for Mandarah strain

CONCLUSION

It can be very clear that, each chicken strain has special requirements of temperature during of embryonic developments and that is the basic of the suggested temperature schemes.

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