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SHELL PHYSICAL CHARACTERISTICS AND MINERAL CONTENT OF HATCHED AND NON HATCHED OSTRICH (*STRUTHIO CAMELUS*) EGGS

By

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Abstract: *A total of 100 ostrich eggs were collected to study the effect of egg weight loss during incubation, shell physical characteristics and shell mineral contents on hatchability. Initial and final (after 39 days of incubation) egg weights, egg weight loss during incubation, egg size, egg fertility and egg hatchability were determined. Egg shells were collected from the hatchery and classified into shells from hatched and from non-hatched (late dead in shell) eggs. Egg shell characteristics (egg shell weight as percentage of egg weight, egg shell porosity and egg shell thickness) and shell mineral contents of Ca, P, Mg, Zn, and Mn were determined. The obtained results cleared that:*

1- *There were no significant differences between hatched and non-hatched ostrich eggs in mean initial egg mass at set, egg size (length and width in cm), egg shell weight after hatch, egg shell thickness (mm) and mean egg shell porosity.*

2- *The hatched eggs had an insignificantly higher porosity than the non-hatched eggs and the percentage of eggs with low porosity (8-12 pore/cm2) was significantly higher in non-hatched eggs (30%) than in hatched ones (5.5%).*

3- *The percentage of abnormal egg weight loss (less than 13% and higher than 17%) was significantly higher in non-hatched than in hatched eggs indicating that the reduction in hatchability may be due to low or high egg weight loss during incubation.*

4- *At hatching time, weight of the dead in shell embryos was significantly higher (941.1±15.3) than that in hatched chicks (717.3±16.5) may be due to water retention by chick as a result of failure to lose sufficient water during incubation.*

5- *The egg shell content of calcium, manganese, and the ratios of Ca to P and Ca to Mg were significantly higher in non-hatched eggs than in hatched ones.*

6- *The eggshell content of phosphorus and Magnesium were significantly higher in hatched eggs than in non-hatched eggs.*

7- *The significantly higher Mg in hatched than in non-hatched eggshells caused a significantly lower Ca/Mg ratio in eggshells of hatched than in non-hatched eggs.*

8- *There was no significant difference between hatched and non-hatched eggs in the zinc content of shell.*

9- *Low egg shell porosity and insufficient percentage weight loss during incubation are the main factors caused the reduction in hatchability.*

INTRODUCTION

The main factors affecting ostrich (Struthio camelus) production are: low fertility, low hatchability, high chick mortality and growth rate from hatch to slaughter age. These factors in addition to marketing act as major obstacle and difficulties to the development of ostrich farming and have limited success to the world ostrich industry.

Hatchability of artificially incubated ostrich eggs was generally low and it was less than or about 50% (Deeming, 1995a) and 50 to 84% of fertilized eggs (Deng, 2004). In addition, Mellett (1993) and More *et al*., (1994) reported that on average 50% of ostrich eggs had hatched and only 40% of the hatching had survived to slaughter age.

Deng (2004) concluded that the main factors affecting hatchability are: Nutrition level (energy, protein and fiber contents in diet), humidity, turnover rate (not less than 6 times/24 hrs) and storage time (<10 days). The incubator humidity is best measured by percentage of egg weight loss during the 39 days of incubation (13-17% by Saito *et al*., 1999 and around 15% by Schalkwyk *et al*., 2000). Meanwhile**,** RIRDC (1997) summarized the main ostrich incubation and hatchery problems as: Low fertility, bacterial & fungi infection (caused about 66.7% of early to mid term and 63% of late embryonic death), embryo malposition (represented 33% of the late death), shell quality (porosity, shell thickness, floating air cell) and extreme egg weight.

Furthermore, hatchability of the egg and the production of a healthy chick depend on two main factors; first, the contents of egg at laying must supply all the water and chemical energy in the form of macronutrients needed for embryo development, and second the eggshells allow into the egg sufficient oxygen to meet the demands of the embryo and the appropriate quantities of water vapor and carbon dioxide to pass out (Ar, 1991).

Consequently, egg shell quality is one of the main factors affecting hatchability. Stewart (1995) attributed the difficult in ostrich artificial incubation to the great variation in the egg quality between the incubated eggs compared to chicken eggs. In addition, Black (1994) indicated that poor quality shells such as high or low porosity, thin or thick shells, excessive ridging rebilling or stress lines and other deformities which interfere with gas exchange are factors that affect significantly the percent of hatchability.

Sahan (2002) concluded that edema and malposition due to insufficient water egg loss during incubation are the primary symptoms in late-term ostrich embryonic mortality.

The present study was carried out to study the role of egg quality and egg shell mineral contents on hatchability of ostrich eggs.

MATERIALS AND METHODS

The present study was carried out on a total number of 100 ostrich eggs weighed between 1300 and 1500 g. Eggs were obtained from two local farms during the peak egg production (from May to July 2003) to study the effect of egg shell physical characteristics and its mineral content on hatchability.

Egg Collection:

Eggs were collected daily as soon as possible after laying from the breeder stock, cleaned and disinfectant immediately as described by Deeming (1997). Each egg was numbered and identified with a permanent marker. Eggs were stored for up to 7 days in a clean storage room at 18 °C and 69 % relative humidity as recommended by Gonzalez *et al*., (1999).

Egg Incubation:

Eggs were set in metal – framed egg trays in a vertical position, placed in a commercial multistage incubator with a maximum capacity of 500 ostrich eggs. Eggs were artificially incubated at 36.5 °C and 25 % RH and were turned 90° every 3 hours (8 times a day) up to 39 days. Eggs were candled at 14, 21 and 39 days of incubation and unfertile eggs were excluded. On day 39, the fertile eggs were transferred to plastic hatcher baskets in the hatcher up to 45th day. The temperature and humidity profile during hatch were 36 °C and 40 % RH. Eggs were candled and checked during hatching period. Eggs were allowed to hatch as possible, although, some chicks which had piped were helped by using the method described by Deeming *et al*., (1993).

The following parameters were measured on each egg:

Egg Weight: The egg weight at day 1 of incubation (at the time of setting) was recorded with an electronic digital balance with accuracy of ± 0.01 g.

Egg size: The egg maximum length (long axis, L) and width (short axis, W) were measured in cm by using caliber (1 mm accuracy).

Egg Fertility: Fertility was calculated by the following formula:

$$\text{Fertility}\,\% = \frac{(\text{All setting eggs} - \text{Infertile eggs})}{\text{All setting eggs}} * 100$$

Egg hatchability %: Hatchability (%) from fertile eggs were calculated by the following equation :

$$\text{Hatchability}\,\% = \frac{\text{Number of hatched eggs}}{\text{Number of fertile eggs}} * 100$$

Percentage of egg weight loss during incubation:

Percentage of egg weight loss (EWL%) during incubation was determined according to Gonzalez *et al*., (1999) by the following formula:

$$\text{EWL}\% = \frac{(\text{Egg weight day}\,1 - \text{Egg weight day}\,40)}{\text{Egg weight day}\,1} * 100$$

Egg shell parameters:

At the end of incubation period (45 days) the fertile eggs were classified into two groups; hatched and non-hatched eggs. The egg shells of each group were collected, cleaned of adhering shell membrane, washed with distilled water to remove all albumen and dried over night at 60 °C then ached. The following parameters were determined:

Eggshell Percent:

The eggshell percent was calculated according to equation of Christensen *et al* (1996).

$$\text{Egg shell}\,\% = \frac{\text{Egg shell weight}}{\text{Egg weight}} * 100$$

Egg shell porosity:

Egg shell porosity was determined by averaging pore count obtained from discretionary sampling at 5 independent 1cm^2 sites on an egg surface. The sites were chosen approximately equidistant along the equator to better visualize and facilitate a more accurate counting of porosity. Each selected site was dyed with a food-grade blue dye before counting. A clear dichotomy of pore size, small and large, was observed according to Gonzalez *et al*., (1999).

Egg shell thickness:

Egg shell thickness was obtained by averaging thick measurement made at the same five shell sites used to determine porosity. A slip clutch micrometer was used to make individual thick estimate to the nearest 0.01 mm.

Egg shell mineral content:

The egg shell contents of Ca, Mg, Zn and Mn, were determined by using Atomic Absorption Spectrophotometer (Buck Scientific, Model 210 VGP). Shell P was determined using the calorimetric technique of Goldenberg and Fernandez (1966).

Post-hatch chick's weight:

Post-hatch chicks were weighed just after completely hatched using an electronic balance accurate to ± 0.01 g. The non-hatched eggs were opened at the 43rd day when candling revealed that the chick was died and chick was weighed after removal of all membranes.

Statistical analysis:

Data were analyzed using statistical analysis system software (SAS, 1988). Student t test (Procedure TTEST of SAS) was used to test the significance between hatched and non-hatched groups. Cross tabulation and Chi square test (Procedure Frequency of SAS) were used to compare prevalence of egg weight loss and shell porosity in the two groups.

RESULTS AND DISCUSSION

1- Effect of ostrich egg physical characteristics on hatchability:

Hatchability of ostrich eggs and production of a healthy chick depend on egg quality, which refers to the egg contents and the eggshell. So, increasing or not the embryonic mortality during piping and hatching depends first on the characteristics of the egg itself, which were determined prior to laying. Therefore, the successful artificial incubation as measured by maximizing hatchability of fertile eggs depends on studying some physical characteristics of the hatched and non-hatched ostrich eggs.

Table (1) reveals that there were no significant differences between hatched and non-hatched ostrich eggs in mean initial egg mass at set, egg dimensions (length and width in cm), eggshell weight after hatch, eggshell thickness (mm) and mean egg shell porosity.

1-1- Effect of ostrich egg weight and size on hatchability:

Table (1) shows that egg weight, egg length and egg width did not differ significantly between hatched and non-hatched eggs indicating that in the present study egg weight and dimensions did not affect hatchability because they were within the normal ranges reported for ostrich eggs. Meir and Ar (1990) stated that the length and width of normal ostrich eggs were 15.32 cm and 12.56 cm, respectively, which are in accordance with that found in the present study. On the other hand, Simon and More (1996), Krawinkel (1994) and Ar *et al.*, (1996) reported that egg size and weight had a significant effect on hatching rate which was due to lower hatchability in large and small eggs (28 and 14 %, respectively, lower than average eggs). It is worth noting that the mean egg weight in the present study (1153 vs. 1190 gm for hatched and non-hatched eggs, respectively) was far from the range of low and large eggs weights that affecting hatchability. Wilson (1991) postulated that eggs weighing less than 1000g or more than 1800g have reduced hatchability. The effect of egg size on hatchability was explained by Deeming (1997) who stated that the effect of egg size on hatchability was due to a reduction in the surface area to volume ratio with increasing egg size making the gas heat exchange more difficult.

1-2- Effect of ostrich egg weight loss during incubation on hatchability:

Table (1) indicates that the mean percent egg weight loss during incubation was significantly higher in hatched than in non-hatched eggs. Also, Table (2) shows that the percentage of eggs with recommended egg weight loss during incubation period (13-17%) was significantly higher in hatched (95.5%) than in non-hatched eggs (40.0%). Similar results were reported by Nahm (1999) who found that the weight loss of fertile ostrich eggs (14.2%) during the 40 days of incubation was significantly higher in the egg that hatched than in those that failed to hatch. He added that the longer periods of storage between laying and incubation resulted in significantly more non-hatched eggs. Blood *et al*., (1998) and Saito *et al*., (1999) showed that embryonic deaths were curve linearly related to evaporative water loss to day 35 of incubation and the higher death rates occurred in eggs with <10% and >19% water loss. They postulated that the percentage weight losses during the incubation of the egg hatched were 0.33% per day and the fertile eggs that did not hatch had higher or lower percentage weight loss.

Many authors reported different percent of egg weight loss to achieve successful hatching percent under artificial conditions e.g., 12-15.5% (Jarvis *et al*., 1985 and Simon and More, 1996), 10-13% (Bowsher, 1992), 13.2% (Wilson *et al*., 1997), 14.2% (Nahm, 1999) and 15% (Deeming, 1993). Moreover, Saito *et al*., (1999) reported that both lower and higher water losses resulting decreased hatchability and the eggs that do hatch with water losses below 10% produced edematous, sluggish and unabsorbed yolk chicks. Consequently, the failure to lose sufficient weight can result in water retention by the chick which can reduce hatchability. Furthermore, Angle (1995) and Sahan (2002) stated that most edema was generally considered to result from insufficient water loss from the egg during incubation. Deeming (1993) demonstrated that insufficient water loss result in poorly developed air cells, poor gas exchange and wet or ‘water-logged‘ edematous embryos, many of which die at or near point of hatch or soon after. Also, low water losses (<13%) indicate low permeability of the eggshell to water vapor and other gases. If the permeability is very low then additional problems of oxygen supply or carbon dioxide removal can complicate the survival of the embryos later in development (Tullett and Deeming, 1982). Reduction in hatchability due to high egg weight loss during incubation was explained by Deeming (1993) who reported that excessive water loss results in reduced hatchability though dehydration of embryos and prevents hatching.

1-3- Effect of ostrich egg shell porosity on hatchability:

Table (1) shows that the hatched fertile eggs had significantly higher porosity than the non-hatched eggs (15.62 vs. 14.4 pore/cm^2). Paganelli (1991) stated that pore numbers vary greatly between ostrich eggs and average around 15 pore/cm^2 which is in agreement with the present results.

Moreover, Table (3) shows that the percentage of eggs with low porosity (8-12 pore/cm2) was significantly ($p \leq 0.05$) higher in non-hatched eggs (30%) than in hatched ones (6.52 %). Shell porosity has been implicated with embryonic mortality and had a significant effect on hatchability (Ar, 1991 and Bowsher, 1992). Christensen and Edens (1985) and Satteneri and Satterlee (1994) stated that the porosity of the egg shell may play a big role in hatching egg and both too many pores and too few pores have been shown to affect hatchability. Also, Sahan *et al*., (2003) showed that pore density correlated with hatchability where hatchability was less in low pore density eggs (40.9%) than in intermediate (71.8%) and high pore density eggs (80.9%). Gonzalez *et al*., (1999) reported positive correlations between pore density and egg mass loss and between pore density and hatchability in ostrich eggs.

The effect of porosity on hatchability was explained by Deeming (1993). He reported that “Tight” eggs with low porosity lose little water and this may cause edema (water retention) in ostrich embryos which makes hatching more difficult. He also suggested that low eggshell porosity may limit oxygen supply to the embryo resulting in suffocation without obvious symptoms and the death resulted from hypoxia.

In addition, Wilson (1996) reported that the tremendous variation observed in shell porosity and weight loss of ostrich eggs indicates wide genetic variability among hens. So, improved hatchability is likely to be achieved through selecting hens that lay eggs with good shell quality and adequate, uniform shell porosity.

1-4- Effect of egg shell thickness on hatchability:

Table (1) shows that egg shell thickness had no significant effect on hatched and non-hatched ostrich eggs in the present study. This result is in agreement with Sahan *et al*., (2003) who found that shell thickness didn’t correlate significantly with hatchability. They stated that although the hatchability of high shell thickness eggs (63.6%) was somewhat lower than those of intermediate shell thickness eggs (74.2%) and low shell thickness eggs (71.4%), these differences were not significant. However, eggs of low shell thickness lost more mass (13.03%) than those with intermediate (11.22%) and high (10.36%) shell thickness. So, shell thickness was negatively correlated to egg mass loss. A significant negative correlation between egg weight loss and shell thickness was found by Sahan (2002). Gonzalez *et al*., (1999) reported that although shell thickness did not significantly affect hatchability the shell was thinner in hatched eggs than in the non-hatched ones and that shell thickness and egg mass loss were negatively correlated. Vick *et al.*, (1993) indicated that there are some factors other than shell thickness affected embryonic mortality and development of chicken eggs such as the poor albumen quality and thinner cuticle and shell membrane.

On the other hand, Peeples and Brake (1985) demonstrated that egg shell was a major respiratory component of the developing embryos and the thicker shell produce greater resistance to gaseous diffusion and the shell thickness was associated with increased embryonic mortality. It is of interest to note that hatchability was depend upon a proper relationship between pore concentration and shell thickness (pore length) which provided proper weight loss for optimum embryo growth (Satteneri and Satterlee, 1994; Christensen *et al.*, 1996 and Deeming 1997). Moreover, Saleh (1988) showed that shell thickness of different shell regions is consistent with the removal of Ca from eggshell for bone formation during the embryonic development.

1-5- Effect of ostrich chick weight at hatch on hatchability:

In non-hatched eggs, chick weight (gm) at hatch was significantly higher (941.1±15.3) than that in hatched eggs (717.3±16.5) (Table, 4). This higher chick weight at hatch in non-hatched eggs may be due to water retention by chick as a result of failure to lose sufficient egg weight during incubation. Wilson (1991), Button (1993) and Terzich and Vanhooser (1993) showed that the failure of eggs to lose water leads to storing the excess of water in the embryo's skeletal muscles and under the skin resulting in a characteristic edema.

The above results indicate that the low eggshell porosity and percentage weight loss are the main factors caused the reduction in hatchability. These results are confirmed by the low hatchability due to high late death percentage (Table, 1). Burton and Tullett (1983) concluded that hypoxia was the proximal cause of death in edematous embryo as a result of impaired oxygen diffusion across the moist shell membranes. Meanwhile Sahan (2002) concluded that edema and malposition due to insufficient water egg loss during incubation are the primary symptoms in late-term ostrich embryonic mortality. Furthermore, death of near term chicks may be due to myopathy. Deeming (1995b) found that myopathy was contributed to muscular fatigue and failure to hatch. Myopathy was thought to occur secondarily to exertion, hypoxia and respiratory acidosis and this may be more direct causes of death in chicks which exhibiting this symptom.

2- Effect of ostrich egg shell minerals content on hatchability:

The mean egg shell mineral content of hatched and non-hatched ostrich eggs are presented in Table (5). The statistical analysis indicated that the egg shell content of calcium (Ca), manganese (Mn), calcium to phosphorus ratio (Ca/P) and calcium to magnesium ratio (Ca/Mg) were significantly higher in non-hatched eggs (late dead in shell) than in hatched ones. On the other hand, the egg shell content of phosphorus (P) and Magnesium were significantly higher in hatched eggs than in non-hatched eggs. Meanwhile, egg shell content of zinc (Zn) did not differ significantly between hatched and non-hatched eggs.

The significantly higher Ca/P ratio in non-hatched than in hatched egg shells was due to a significantly lower egg shell Ca in hatched than in non-hatched eggs (14.9 vs. 17.3, respectively), while egg shell P was significantly higher in hatched than in non-hatched eggs. The lower Ca content in egg shell of hatched eggs may be due to Ca mobilization from egg shell for bone formation during the embryonic development during incubation. Saleh, (1988) showed that shell thicknesses of different shell regions are consistent with the removal of Ca from egg shell for bone formation during the embryonic development. Moreover, he reported that the thin shell of hatching eggs may be due to the more consumption of Ca by the live embryos than the dead ones in the non-hatching eggs. Also, Christensen *et al* (1996) showed that the pores became wider during ostrich egg incubation may due to a reduction in the shell thickness with inner surface shell erosion and Ca mobilization. Furthermore, Tuan and Zrike (1978) reported that after the early period of embryonic growth, the primary source of Ca (over 80%) and Mg (over 30%) was mobilized via shell absorption (dissolution of the shell) by the chorioallantoic circulation by mechanisms similar to bone resorption and the shell was the only sources of Ca and Mg late in incubation. Meanwhile, Christensen and Edens (1985) found that there were no significant differences in the amount of Ca in egg shells containing non-hatched or hatched turkeys.

The higher P in hatched than in non-hatched egg shells are in agreement with Christensen *et al*., (1982) who found that the piped egg shells contained significantly more P than non piped or hatched egg shells. Moreover, the significantly higher Mg in hatched than in non-hatched egg shells (Table, 5) caused a significantly lower Ca/Mg ratio in egg shells of hatched than of non-hatched eggs. Similar results were found by Christensen *et al*., (1982) who reported that hatched egg shells contained significantly more Mg than piped or non piped egg shells, the ratio of Ca to Mg increased significantly in the hatched egg shells than piped or non piped egg shells. Tronter *et al*., (1983) found that Mg was lost from membranes of chicken eggs between 3 and 9 days of incubation and Mg concentration of membranes increased after 18 days of incubation so they suggested that Mg played a more complex physiological role during incubation than simply as a structural component of the shell.

The higher Ca/Mg ratio in hatched than in non-hatched egg shells in the present results is contradicting with the high requirement for plasma Ca/Mg ratio during hatching. Christensen and Biellier (1982) stated that increased plasma Ca to Mg ratio in embryos at the time of piping and hatching increased physiological muscular mechanism for breaking the shell and hatching and may play a role in hatchability and that the increased muscular activity due to increased plasma Ca:Mg ratio may be required for the embryo to break and free itself from the shell. Also, Christensen and Eden (1985) found that increasing the ratio of Ca to Mg in turkey eggs at 25 days of incubation improved hatchability whereas decreasing the ratio suppresses hatchability. This contradiction can be explained by the less mobilization of Mg from egg shell in hatched eggs. Christensen and Biellier (1982) reported that ionic Ca stimulates muscular contraction whereas Mg inhibits contraction and suggested that the influx of these ions into the egg membranes or embryonic circulation may influence embryonic survival during incubation. Thus the lower Mg content in eggshell of non-hatched eggs may indicate that more Mg was mobilized from the egg shell causing the inhibition of muscle contraction and failure to hatch.

The significantly higher Mn in egg shells of non-hatched than of hatched eggs may reflect the lower mobilization of Mn from shells of non-hatched eggs and may affect the ability of chick to hatch. Wallach (1970) stated that deficiencies in Mn, Zn, methionine or choline may cause limb deformity.

It can be concluded that, the lower hatchability in normal size ostrich eggs was mainly due to high late dead percentage resulting from high (>17%) or low (< 13%) egg weight loss during incubation period or to low egg shell porosity which affects egg weight loss and embryo respiration. Thus low egg shell porosity is the main factor affecting hatchability as eggs with low porosity lose little water and this may cause edema (water retention) in ostrich embryos which makes hatching more difficult. Also, low egg shell porosity may limit oxygen supply to the embryo resulting in suffocation without obvious symptoms and the death resulted from hypoxia. Egg shell content of calcium, manganese, and the ratios of Ca to P and Ca to Mg were significantly higher in non-hatched eggs than in hatched ones indicate that the dead in shell may be due to impairment in mobilization of these minerals from egg shell during embryo development.

Table (1): Mean ±S.E. of physical characteristics of hatched and non-hatched ostrich eggs.

Egg physical characteristics	Egg Class	
	Hatched	Non-hatched*
Initial Egg wt. at set (gm)	1355±34.68^{a}	1378± 44.3^{a}
Egg wt. at 39d of incubation (gm)	1153± 18.8^{a}	1190±24.03^{a}
Egg length(cm)	15.12± 0.11^{a}	15.31± 0.15^{a}
Egg width(cm)	12.23± 0.07^{a}	12.25± 0.09^{a}
Egg shell wt. (gm)	237±5.43^{a}	249± 6.9^{a}
Percentage wt. loss	14.6±0.2^{a}	13.6±0.26^{b}
Egg shell porosity (pore/cm2)	15.62± 0.57^{a}	14.4± 0.57^{a}
Egg shell thickness (mm)	1.835± 0.0029^{a}	1.8± 0.0037^{a}

*late dead in shell

a,b means in the same row with different superscripts are significantly different at $P<0.05$

Table (2): Prevalence of percentage weight loss in hatched and non-hatched ostrich eggs.

Egg wt. Loss (%)	Hatched		Non-hatched		
	No.	%	No.	%	p
<13%	2.0	4.55	12	40.00	≤0.01
13-17%	42.0	95.45	12	40.00	
>17%	0.0	0.00	6	20.00	
Total	44.0	100.00	30	100.00	

Table (3): Prevalence of egg shell porosity in hatched and non-hatched eggs.

Egg shell porosity (pore/cm2)	Hatched		Non-hatched		
	No.	%	No.	%	p
8-12	3	6.52	9	30.00	≤0.05
12-18	35	67.09	16	53.33	
>18	6	17.39	5	16.67	
Total	44	100.00	30	100.00	

Table (4): Mean ±S.E. weight of hatched and non-hatched ostrich chicks.

	Hatched	Non-hatched
Chick wt. at hatch (gm)	717.3±16.5^{b}	941.1±15.3^{a}

a,b means in the same row with different superscripts are significantly different $P<0.05$.

Table (5): Eggshell mineral content (Mean ± SE) of hatched and non-hatched ostrich eggs.

Mineral	Hatched	Non-hatched*
Ca%	14.9 ± 0.04^{b}	17.3 ± 0.05^{a}
P%	0.398 ± 0.03^{a}	0.167 ± 0.04^{b}
Mg%	0.7 ± 0.05^{a}	0.60 ± 0.06^{b}
Zn%	0.114 ± 0.0084^{a}	0.11 ± 0.0107^{a}
Mn%	0.077 ± 0.005^{b}	0.133 ± 0.0065^{a}
Ca / P ratio	37.5 ± 1.3^{b}	103.9 ± 1.3^{a}
Ca / Mg ratio	21.38 ± 0.8^{b}	28.7 ± 0.83^{a}

*late dead in shell

a,b,c means in the same row with different superscripts are significantly different at $P<0.05$

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الملخص العربى

الصفات الطبيعية والمحتوى المعدنى لقشرة بيض النعام الفاقس وغير الفاقس

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تم استخدام عدد ١٠٠ بيضة نعام لدراسة بعض المقاييس الطبيعية للقشرة وكذلك محتواها من العناصر المعدنية وتأثير ذلك على نسبة الفقس. تم تقدير كل من وزن البيض - حجم البيض - نسبة الخصوبة – الوزن المفقود من البيضة خلال التفريخ - ونسبة الفقس.

تم جمع وتقسيم قشر البيض الناتج من المفقس إلى مجموعتين : قشر بيض فاقس وقشر بيض كابس (نفوق متأخر) وتم تقدير الصفات الاتية:

مسامية القشرة - سمك القشرة - نسبة قشرة البيض من البيضة الكلية و تقدير محتوى هذا القشر من الكالسيوم-الفوسفور-الماغنسيوم-المنجنيز-الزنك.

كانت أهم النتائج التى تم التوصل إليها:

١. لم يكن هناك اخلافات معنوية بين بيض النعام الفاقس و الغير فاقس فى متوسط وزن البيض عند التفريخ -حجم البيض (المحور الطويل و ا لمحور القصي) - سمك القشرة - وزن القشرة الكلى للبيضة بعد الفقس - مسامية القشرة.

٢. كانت نسبة الفقد الغير طبيعى في وزن البيض (الأقل من ١٣ % والأكبر من ١٧ %) أكثر معنويا فى البيض الغير فاقس عن البيض الفاقس مما أدى إلى انخفاض نسبة الفقس خلال التفريخ.

٣. كان هناك تأثير غير معنوي لعدد الثغور (المسامية) لقشر البيض الفاقس عن الغير فاقس. بينما كان هناك تأثير معنوي لانخفاض المسامية في البيض الغير فاقس (٨-١٢ ثغر لكل سنتيمتر مربع) فكانت النسبة ٣٠ % مقارنة ب ٥,٥ % للبيض الفاقس.

٤. لم يكن هناك اختلاف معنوى بين قشر البيض الفاقس والغير فاقس فى وزن البيض و سمك القشرة ومحورى البيضة مما يوضح أن وزن البيض ومحورى البيضة الطويل والقصير في هذه الدراسة تقع فى المدى الطبيعي لبيض النعام وبالتالى لم يؤثر ذلك على نسبة الفقس.

٥. كان هناك زيادة معنويه فى وزن الكتكوت في البيض الغير فاقس (٩٤١,١ ± ١٥,٣ جم) عن وزن الكتكوت الفاقس (٧١٧,٣ ± ١٦,٥جم) وربما يرجع ذلك إلى احتجاز الكتكوت لكمية من الماء داخله وعدم قدرته على فقد هذا الوزن أثناء التفريخ.

٦. كان هناك زيادة معنوية لمحتوى قشر بيض النعام الغير فاقس من الكالسيوم والمنجنيز و نسبة الكالسيوم إلى الفوسفور وأيضا نسبة الكالسيوم إلى الماغنسيوم مقارنة بقشر البيض فاقس.

٧. كان محتوى قشر البيض الفاقس من الفوسفور و الماغنسيوم أكثر معنويا عن قشر البيض الغير فاقس.

٨. لم يكن هناك أى اختلاف معنوي فى محتوى القشر الفاقس والغير فاقس من الزنك.

٩. كان الارتفاع المعنوي للماغنسيوم فى قشر البيض الفاقس عن الغير فاقس مصحوبا بانخفاض معنوي لنسبة الكالسيوم إلى الماغنسيوم في قشر البيض الفاقس عن القشر الغير فاقس.